ISSN 0701-581X

Wildlife Habitat Handbooks for British Columbia: Problem Analysis

by A.P. Harcombe
April 1984

Ministry of Environment

Ministry of Forests

Copies of Fish and Wildlife Bulletins are available, depending on supply, from the British Columbia Fish and Wildlife Branch, Ministry of Environment, Parliament Buildings, Victoria, B.C. V8V 1X5.

No. R-1 Ungulate use of some recently claimed strip mines in southeastern British Columbia. E.A. Stanlake, D.S. Eastman, and M.G. Stanlake. February 1978. 82pp.

No. R-2 Effects of selective logging on arboreal lichens used by Selkirk caribou. Susan K. Stevenson. November 1979. 75pp.

No. R-3 Seasonal movements of black-tailed deer on northern Vancouver Island. A.S. Harestad. December 1979. 98pp.

No. R-4 A history of the pheasant in the Okanagan Region of southern British Columbia. D.J. Spalding and R.P. Stoneberg. December 1981. 64pp.

No. R-5 A manual for the identification by epidermal characteristics of some forage plant species of the southern interior of British Columbia. B.M. Wikeem and M.D. Pitt. May 1983. 144pp.

No. R-6 The breeding ecology and management of white pelicans at Stum Lake British Columbia. D.L. Dunbar. In prep.

No. R-7 Relationships among black-tailed deer population trends, winter range hunting and wolves in the Nimpkish Valley, Vancouver Island. G.W. Jones and B. Mason. August 1983. 26pp.

No. R-8 Aspects of social organization and diurnal activity patterns o California bighorn sheep (Ovis canadensis california Douglas 1829). R Eccles. In prep.

No. R-9 Foraging ecology and nutrition of Stone's sheep. D.R. Seip. Octobe 1983. In prep.

No. R-10 Wildlife habitat handbooks for British Columbia: problem analysis. A.P Harcombe. April 1984. 237pp.

ISSN 0701 - 581X

WILDLIFE HABITAT HANDBOOKS FOR BRITISH COLUMBIA: PROBLEM ANALYSIS

A cooperative effort of the
Ministry of Environment (Surveys and
Resource Mapping Branch; Fish and Wildlife Branch)
and the Ministry of Forests (Research Branch)

Andrew P. Harcombe
Habitat Handbook Coordinator
Ministry of Environment
Kamloops, B.C.

Wildlife Habitat Research WHR-8
Fish and Wildlife Report No. R-10
MOE Technical Report 8

April 1984

Copies of this report may be obtained, depending on supply, from:

Research Branch
Ministry of Forests
1450 Government Street
Victoria, B.C.
V8W 3E7

or

Information Services Branch
Ministry of Environment
780 Blanshard Street
Victoria, B.C.
V8V 1X5

Citation: Harcombe, A.P. 1984. Wildlife habitat handbooks for British Columbia: problem analysis. Ministries of Forests and Environment. Wildlife Habitat Research WHR-8, Fish and Wildlife Report No. R-10, MOE Technical Report 8. 237pp.

Photograph by G. Swannell

"science seeks for understanding ...
simplicity is the hallmark of understanding"
C. S. Holling 1982

PREFACE

The Habitat Handbook Coordinating Committee was formed in 1981 to provide direction for a program called "The Development of Wildlife Habitat Handbooks for the Forest and Rangelands of B.C. and Associated Projects." The program goal is "to develop planning tools that aid wildlife habitat management", in recognition of the increased need for managers to make better use of the opportunities for indirect habitat management afforded by nonwildlife resource activities such as logging. A project was proposed by the Coordinating Committee, with review by regional and headquarter staff in the Ministries of Environment and Forests. The Kamloops area was designated as the location for the development of a pilot wildlife habitat handbook, using the United States handbooks as a guide.

Andrew P. Harcombe was assigned to the project as the coordinator, and placed in Kamloops. The present report represents a problem analysis of the proposed habitat handbook program. This report includes analysis of existing handbook documents, interviewing various resource user representatives, examining recently-acquired unpublished reports, and close coordination with handbook producers in the United States. The problem analysis concludes with recommendations for developing British Columbia handbooks.

The document should serve as more than just a summary of existing reports and a compilation of references. It should provide the direction, for both the pilot handbook and the proposed seven other handbooks to complete provincial coverage, by developing analytical and interpretative systems enabling handbook production.

This project is jointly sponsored by several groups, with responsibilities and procedures defined within a memorandum of agreement (see Appendix 11.1). The problem analysis has been reviewed and has had its recommendations accepted and supported by all Steering Committee members. Outside review has been done by Hal Salwasser, Jim Pojar, Jim van Barneveld, Ralph Ritcey, Bill Munro, Fraser Russell, Rick Morley, Dene Ferguson, Ray Addison, and Carl Highsted.

B. Pendergast
January 1984

PREFACE TABLE

Members of the Handbook Coordinating Committee

B. Pendergast (Chairman)
Head, Wildlife Unit
Surveys and Resource Mapping Branch
Ministry of Environment
Victoria, B. C.

Dr. F. Bunnell
Professor, Faculty of Forestry
University of British Columbia
Victoria, B. C.

R. W. Campbell
Associate Curator
Vertebrate Zoology Division
Provincial Museum
Ministry of Provincial Secretary and Government Services
Victoria, B. C.

Dr. D. Eastman
I/C Wildlife Research
Fish and Wildlife Branch
Ministry of Environment
Victoria, B. C.

Dr. A. Harestad
Associate Professor
Department of Biological Sciences
Simon Fraser University
Burnaby, B.C.

R. Ellis
Manager, Wildlife Habitat Research
Research Branch
Ministry of Forests
Victoria, B. C.

R. Silver
I/C Land Management
Fish and Wildlife Branch
Ministry of Environment
Victoria, B. C.

B. Nyberg
Research Wildlife Ecologist
Vancouver Region
Ministry of Forests
Vancouver, B. C.

TABLE OF CONTENTS

Page

PREFACE i

TABLE OF CONTENTS iii

LIST OF FIGURES vii

LIST OF TABLES viii

ACKNOWLEDGEMENTS ix

SUMMARY x

SUMMARY RECOMMENDATIONS xii

1 INTRODUCTION 1
1.1 The Ecological Setting 1
1.2 The Legislative System 1
1.3 The Need 4
1.4 The Solution 6
1.5 Goal of the Wildlife Habitat Handbook Program 6
1.6 Program Organization 7

2 OBJECTIVES 9

3 REVIEW OF LEGISLATION, GOALS AND POLICIES 11

3.1 Organization of Agencies 11
3.1.1 Ministry of Environment 11
3.1.2 Ministry of Forests 14
3.1.3 Ministry of Lands, Parks and Housing 17
3.2 Legislation 17
3.2.1 Introduction 17
3.2.2 Ministry of Environment Legislation 17
3.2.3 Ministry of Forests Legislation 19
3.2.4 Ministry of Lands, Parks and Housing Legislation 20
3.2.5 Federal Government Legislation 21
3.2.6 Strength and Weaknesses of Legislation 21
3.3 Goals and Policies of Planning and Management 22
3.3.1 Introduction 22
3.3.2 Ministry of Environment 23
3.3.3 Weaknesses of the Goals and Policies of the Ministry of Environment 27
3.3.3.1 Diversity 28
3.3.3.2 Viability 31
3.3.3.3 Capability 31
3.3.3.4 Biophysical Zones 31
3.3.3.5 Sufficient Abundance 32
3.3.3.6 Conclusions 32
3.3.4 Ministry of Forests 33
3.4 Interagency Planning Processes for Land and Resources 39
3.4.1 Introduction 39

3.4.2 Environment and Land Use Committee 39
3.4.3 Environment and Land Use Technical Committee 40
3.4.4 Regional Planning Processes 40
3.4.5 Strengths and Weaknesses of the Planning Processes 44
3.5 Sources of Wildlife Information 46

4 HABITAT HANDBOOKS IN THE UNITED STATES 49
4.1 Background and Related Legislation 49
4.2 Wildlife and Fish Habitat Relationships Program 50
4.3 Program Coordination 52
4.4 Progress 55
4.5 Strengths and Weaknesses 55
4.6 Habitat Handbook of the Western United States 56
4.6.1 Species Narratives 57
4.6.2 Habitat Classification 59
4.6.3 Featured Species 62
4.6.4 Featured Habitats 65
4.6.5 Species/Habitat Matrices 65
4.7 Computerized Data Bases 71

5 WILDLIFE PLANNING: PRINCIPLES, PRESENT SITUTATION, AND PROJECTED NEEDS 77
5.1 Role and Principles of Wildlife Planning 77
5.2 Present Processes and Needs 79
5.3 Proposed Solution to Meeting Needs 80
5.4 The Justification 81
5.5 The Future: Changing Directions and Needs 83

6 CRITERIA, OPTIONS, AND RECOMMENDATIONS 87
6.1 Introduction 87
6.2 Geographical Area for Handbook Coverage 87
6.2.1 Introduction 87
6.2.2 Wildlife Ecosystem Regions 89
6.2.3 Terrestrial Biotic Areas 90
6.2.4 Biogeoclimatic Zonation 93
6.2.5 Biophysical Vegetation Regions 95
6.2.6 Forest Regions 95
6.2.7 Ecoregions 97
6.2.8 Administrative Units 99
6.2.9 Discussion 99
6.2.10 Recommendation 100
6.3 Authorship: Preparation of Handbook Components 100
6.3.1 Discussion 100
6.3.2 Recommendation 104
6.4 Authorship: Coordination and Technical Editing 105
6.4.1 Discussion 105
6.4.2 Recommendation 106
6.5 Presentation Opportunities 106
6.5.1 Discussion 106
6.5.2 Recommendations 109
6.6 Requirements for the Wildlife Habitat Handbook 109
6.7 Species Notes 111
6.7.1 Discussion 111
6.7.2 Recommendation 113

6.8 Wildlife - Habitat Relationships 113
6.8.1 Discussion of Wildlife Habitat Relationships and the Basic Models 113
6.8.2 Habitat Classification 118
6.8.2.1 Discussion 118
6.8.2.2 Biophysical Vegetation Classification System 122
6.8.2.3 Forest Service Ecosystem Classification System 124
6.8.2.4 Forest Cover Inventory Mapping System 126
6.8.2.5 Recommendations for Habitat Classification System .. 127
6.8.2.6 Successional Stages 128
6.8.2.7 Recommendations for Successional Stages 135
6.8.2.8 Canopy Closure 136
6.8.2.9 Recommendations for Canopy Closure 140
6.8.3 Specific Habitat Elements..... 141
6.8.3.1 Discussion 141
6.8.3.2 Recommendations 141
6.8.4 Life Requisites 145
6.8.4.1 Discussion 145
6.4.4.2 Recommendation 145
6.8.5 Capability Coefficients 146
6.8.5.1 Discussion 146
6.8.5.2 Recommendations 148
6.8.6 Season of Use 148
6.8.6.1 Discussion 148
6.8.6.2 Recommendations 153
6.9 Detailed Species-Habitat Models 153
6.9.1 Introduction 153
6.9.2 Selection of Featured Species 153
6.9.2.1 Discussion 153
6.9.2.2 Recommendation 158
6.9.3 Selection of Featured Habitats 159
6.9.3.1 Discussion 159
6.9.3.2 Recommendation 159

7 HABITAT HANDBOOK PROGRAM PROPOSAL 161
7.1 Introduction 161
7.2 Concepts and Principles 161
7.3 Habitat Classification System 163
7.4 Wildlife - Habitat Relationships 163
7.5 Wildlife - Habitat Evaluation: The Planning Process 163
7.6 Vegetation Management 165
7.7 Case Histories 167
7.8 Implementation 167

8 WORKING PLAN 173
8.1 Content 173
8.2 Scheduling 174
8.3 Concurrent activities 174
8.4 Authorship 175
8.5 Research 176
8.6 Budget 176

9 RECOMMENDATIONS 177

10 REFERENCES 181

11 APPENDICES 203
11.1 Memorandum of Agreement: The Development of Wildlife Habitat Handbooks 203
11.2 Wildlife Habitat Handbook for the Forests and Rangelands of B. C. and Associated Projects: Final Proposal 208
11.3 Personnel Contacted 215
11.4 Glossary 217

LIST OF FIGURES

Figures		Page
1	Ecoregions of Canada	2
2	Wildlife adminstrative regions in British Columbia	12
3	Management units of the Thompson-Nicola region	13
4	Administrative forest regions of the B. C. Ministry of Forests	15
5	Proposed Timber Supply Areas of British Columbia	16
6	Administrative units of the B. C. Ministry of Lands and Housing	18
7	Hierarchy of planning levels in the B. C. Ministry of Forests	35
8	Folio plan areas in the Kamloops Forest Regions	41
9	CRMP areas in the Kamloops Forest Region	43
10	Relationships between land resources, inventories, analytical models, habitat evaluation methods, research, and multi-resource decision processes	54
11	Example of species narrative	58
12	Matrix of species/habitat relationships from California	67
13	Key to matrix in Figure 12	68
14	Matrix of species/habitat relationships from Oregon	69
15	Matrix of species/plant community relationships	72
16	Matrix of species/successional stages relationships	73
17	Matrix of species/special and unique habitats relationships	74
18	Proposed parallel relationship to wildlife management in the United States and British Columbia	82
19	Wildlife ecosystem regions of British Columbia	91
20	Terrestrial biotic areas of British Columbia	92
21	Biogeoclimatic zones of British Columbia	94
22	Biophysical vegetation regions of British Columbia	96
23	Forest regions of Canada	98
24	Proposed wildlife habitat handbook areas for British Columbia	102
25	Proposed pilot project area: the Southern Interior	103
26	Proposed authorship coordination/technical editing framework	107
27	Changes in patterns in forest succession	115
28	Hypothetical models depicting secondary succession	130
29	Successional stages for forested communities	131
30	Successional stages for forested communities when climax trees are in successional stages	131
31	Overlap in secondary successional sequences between different plant communities	132
32	Structural conditions for rangeland plant communities	133
33	Successional community types related to structural stages of a habitat type	134
34	Relationship of herbage production to percent tree canopy	138
35	Relationship of shrub cover to overstory crown cover in mixed coniferous forest	138
36	Relationship of herbage and shrub production to increasing levels of tree canopy cover	139
37	Life form descriptions	156
38	Guild blocks for two vegetative communities	157
39	Process of habitat evaluation	164
40	Validation model in habitat evaluation process	166
41	Anticipated changes in successional stage or condition because of management activities	168
42	Anticipated changes in range-community structural conditions because of management activities	169
43	Hypothetical association of forestry practices to a generalized rotation cycle, related to successional stage conditions	170

LIST OF TABLES

Tables		Page
	Preface Table	ii
1	Scheme for a third-order ecosystem regionalization	3
2	Priority categories of wildlife species groups for British Columbia	27
3	Main sources of natural history information	48
4	Utility of different levels of species-habitat relationships models	53
5	Successional stages of tree habitat types in some United States habitat handbook projects	61
6	Canopy closure classes used in some United States habitat handbook projects	63
7	Featured species in some United States habitat handbook projects	64
8	Special habitats in some United States habitat handbook projects	66
9	Ministry of Forests planning systems	85
10	Criteria, options, and recommendations for logistic considerations	88
11	Grouping of wildlife ecosystem units in proposed handbook areas	101
12	Criteria, options, and recommendations for content	112
13	Stocking classes used in Ministry of Forests forest inventory	140
14	Proposed specific habitat elements for British Columbia habitat handbooks (preliminary)	142
15	Potential carrying capacity estimates for ungulate capability class rating	147
16	Proposed system for rating the habitat capability of vegetation types in the California wildlife habitat relationships program	147
17	Proposed capability coefficients for basic species-habitat relationships models	149
18	Coefficients for rating importance of specific habitat elements	150
19	Recommended season of use classes and definitions	152
20	Concepts and principles terminology	162

ACKNOWLEDGEMENTS

This problem analysis was funded by the Surveys and Resource Mapping Branch and the Fish and Wildlife Branch of the Ministry of Environment and by the Research Branch of the Ministry of Forests. The production of this problem analysis depended strongly on the support and cooperation of Steering Committee members and various professional staff. I wish particularly to acknowledge the guidance of Rick Ellis, Ministry of Forests. I also wish to thank those people who, by attending the workshop at Lac le Jeune gave a tremendous boost to this project: Dr. Hal Salwasser, USDA Forest Service, Ft. Collins, Colorado, whose experience with the American wildlife fish habitat relationships program proved invaluable in guiding discussions; Don Eastman; Rick Ellis; Dennis Demarchi; Bruce Pendergast; Dave Low; Fraser Russell; Brian Nyberg; Karen Sadoway; and Dr. Jack Thomas, whose humor and good judgement were a timely input. I would also like to thank Ralph Ritcey and Dave Low who always made time to try to improve my wildlife education. Rod Silver made a valiant attempt to keep the section on legislation and policies correct. Wayne Campbell was most cooperative in providing interaction of the wildlife habitat handbook project and the "Atlas of B. C. Vertebrates" project.

Several people were responsible for the typing; I would like to acknowledge Lynne Foxall, Barb Webb, and Bev Dwyer for this arduous task so competently done. Finally, I would like to thank Gail F. Harcombe for her graphic efforts in drafting most of the figures.

SUMMARY

British Columbia is a province encompassing the greatest diversity of wildlife and habitats in Canada. The responsibility for managing wildlife is with the Ministry of Environment. The responsibility for managing most of the land base (provincially owned) is shared by the Ministry of Forests and the Ministry of Lands, Parks and Housing. Thus, habitat is rarely controlled directly by wildlife managers.

Habitat may be defined as "the sum total of environmental conditions of a specific place occupied by a wildlife species or a population of such species" (Thomas 1979c). Wildlife managers may manage habitat either directly, in the few areas they control, or indirectly by influencing other resource managers to modify their activities for the benefit of wildlife. The latter affects a much larger area. This broader approach complements the growing social concern for the welfare of all wildlife species, including maintaining the present diversity of plant and animal communities. It contrasts with the historic emphasis on management for featured species, usually game and furbearers. It is consistent with the forestry legislative mandate for multiple resource integration, which suggests the need for a new balance in how species are to be favoured within the context of overall resource management.

The common denominator between wildlife and other renewable resources is vegetation (plant community). Vegetation is the foundation of wildlife habitat, the primary source of food and shelter. It is what we change most in timber, range, and surface mining activities. To actively plan vegetation management to accommodate wildlife goals, we need a tool for predicting relationships between the structural characteristics of vegetation being managed and the wildlife outputs possible. An agreement among disciplines on the relationship between change in resource production and change in vegetation structure or successional stage is essential because these changes produce significant changes in outputs, effects, or costs. These needs for a tool and an agreement are especially true for the wildife resource. Existing knowledge on wildlife-habitat relationships can be organized into a format that will allow resource managers to make better analyses and decisions in meeting goals and objectives for wildlife diversity and selected species in coordinated planning and integrated management.

A promising solution to this problem of organization and implementation of knowledge is found in the habitat handbooks and species-habitat models presently being developed by the United States Forest Service for their National Forests and Grasslands. The core of their program is the organization of relevant knowledge on life history characteristics for all vertebrate wildlife species in a readable, understandable format, with information on the relative capabilities of different environments to support wildlife. The goal is to provide information on wildlife habitat to all managers, using a common classification of the landscape to predict consequences of management activities for habitat and therefore for wildlife.

A similar approach is recommended for terrestrial vertebrates in British Columbia, with an examination for the inclusion of fish and aquatic habitats to be done later in another study. This problem analysis examines the policy and legislative framework for wildlife and wildlife habitat in the planning systems of British Columbia. The U.S. wildlife fish habitat relationships (WFHR) program is described, and the incorporation of that approach into our provincial wildlife and habitat management is considered.

The consideration of the implementation of a habitat handbook approach considers two broad classes of concepts: logistics and content. Criteria and options are discussed for the logistics of dividing the province into handbook areas, authorship, editing/coordination, and presentation formats. Criteria and options are also discussed for content, which includes the actual components and level of detail for the species habitat relationships models. Three requirements needed as a basis for a complete handbook program for British Columbia were determined to be:

1) a common information set for all wildlife species needed to provide the basis for species-habitat relationships and predictive models;
2) basic wildlife-habitat relationships coefficients for all B.C. terrestrial vertebrate species for use in management and analysis of species richness; the coefficients should show how species relate to habitat classes based on their life requisites, special habitat needs and season of use.
3) detailed wildlife-habitat predictive models for a selected set of species (management indicator species) for use in featured species management; these models would include detailed species-habitat relationships (e.g. habitat suitability indices) in a way that different population levels resulting from habitat change can be predicted.

SUMMARY RECOMMENDATIONS:

The recommendations for logistics of handbook production are:

1) the province should be divided into eight handbook areas, based on wildlife ecosystem regions and subregions
2) the pilot project study area should be the Thompson Plateau and Okanagan Ranges wildlife ecosystem regions
3) authorship of handbook components should be by existing, appropriately qualified government staff whenever possible, provided firm time commitments can be guaranteed
4) other sources of expertise, such as in universities, should be used
5) the initial project should have a single coordinator/editor-in-chief (A. Harcombe) and two technical editors (D. Eastman and R. Ellis) with Harcombe as the overall coordinator of activities
6) the handbook should be published in multiple-volume format so that each chapter can be printed as it becomes ready
7) the data-base should be initially available in hard copy
8) a problem analysis should be carried out on possibilities of setting up a wildlife habitat data-base on a computer-assisted system.

The recommendations for content of the handbook are:

1) Full support should be given to the "B.C. Vertebrate Atlas" program of the B. C. Provincial Museum to produce species notes including information on:
   a) taxonomy
   b) status, abundance, and seasonality
   c) distribution/habitat
   d) special habitat requirements
   e) breeding
   f) territory/home range
   g) food habits
   h) references
   i) other ecological/management features
2) A basic level species/habitat model should be developed, generally for use in planning and management of species richness or diversity at a subregional or smaller scale, that will:

a) be complete for all species in all habitats
b) use a habitat classification that follows the stated selection criteria
c) include successional states in the habitat classification, tying these to ecological or taxonomic habitat units
d) include canopy closure for the dominant layer in the habitat classificaton, divided into the following classes:
(0-25%) sparse cover
(26-65%) moderate cover and
(66-100%) dense cover
e) include specific habitat elements not included in the habitat classification
f) include a consideration of the life requisites of reproduction, feeding, and special needs
g) include capability coefficients (high, moderate, low, not used) on a species-specific basis for subdivisions of each habitat class (structural stage and canopy closure)
h) include coefficients of importance on a species-specific basis for each specific habitat element
i) include a season-of-use designation for each habitat attribute, using combinations of seasons (spring, summer, fall, winter)
j) be accessible from a computer-based system.

3) Detailed predictive models and specific management documents should be developed, generally for use in management planning for featured species management planning at subregional or a larger scale, that will:
a) be completed for all management indicator species in the planning unit, selected from the total species list using a standard set of criteria
b) include quantitative population data suitable for detailed monitoring of habitat manipulation-species responses
c) be completed for selected habitats and/or specific habitat elements that are especially important to a group of species, with an emphasis on management alternatives to improve suitability and availability.

Recommended priorities for the production of a pilot habitat handbook:

1) organize the data base, develop diversity objectives, develop documents on management indicator species and habitats, and describe opportunities for vegetation management
2) develop habitat evaluation and planning coordination processes
3) develop a program for implementing the use of the handbook into the land management and planning system.

Other desirable recommendations, though beyond the direct scope of this problem analysis, are:

1) conduct a problem analysis to select the most appropriate simulation model for modeling plant community changes through time due to management activities
2) better define wildlife management goals, because they are poorly stated and lack any supporting definition or explanation of important concepts, especially regarding population viability and diversity
3) develop a better land use planning process by providing provincial and regional guidelines for overall land planning, ranking resource values and capabilities
4) direct a greater effort towards management of species richness (diversity), with some form of standardization of management indicator species selection for management of featured species.

The second step in the process of developing a habitat handbook is the preparation of a working plan, a blueprint for action that describes the manner in which the problem analysis directions and recommendations are implemented. This working plan will describe the technical detail, detailed handbook outline, scheduling (order and timing), participation, objectives, and projected costs.

1 INTRODUCTION

1.1 The Ecological Setting

British Columbia has a land area of almost 95 million ha with a diverse physiography, climate, fauna, and flora. About 90 percent of the province is in the mountainous Canadian Cordillera, while the northeastern corner is in the flatter Interior Plains region. Of the nineteen ecoregion provinces in three ecosystem domains mapped for Canada (Bailey and Cushwa 1981), seven provinces in two domains are present in British Columbia (Figure 1). Twenty-seven forest cover types for the United States and Canada are found in British Columbia (Eyre 1980). A great diversity of land uses imposed on this mosaic of natural vegetation ensures even greater diversity of habitats (Bunnell et al. 1978). The fauna is composed of 37 reptiles and amphibians, 434 birds, and 140 mammals (excluding sub-species distinction); of these, nearly 90% could be considered nonmarine (having stronger affinities to the terrestrial system). The majority of these species inhabit forested land or grassland, or both. British Columbia has 47.4 million ha of productive forested land (B. C. Ministry of Forests, Information Services Branch 1980b), constituting about 52 percent of the total land base, and an estimated 10 million ha of rangeland (9 million ha of forested range and 1 million ha of open range) (B. C. Ministry of Forests, Information Services Branch 1980c).

1.2 The Legislative Setting

The legislative basis for managing wildlife and habitat is divided among three Ministries. The management of wildlife is a mandate of the Ministry of Environment. The principal goals of the wildlife management program (B. C. Ministry of Environment 1981) are:

1) to maintain the diversity and viability of species representative of the major biophysical zones of the province, and;
2) to ensure that within the constraints of capability of the land and the biological limits of each species, wildlife is available in sufficient abundance to meet the social, recreational, ecological and economic needs of society.

These two goals closely resemble two general production goals in wildlife management described by Thomas (1979a): management for species richness and management for featured species. There is a growing trend in British Columbia

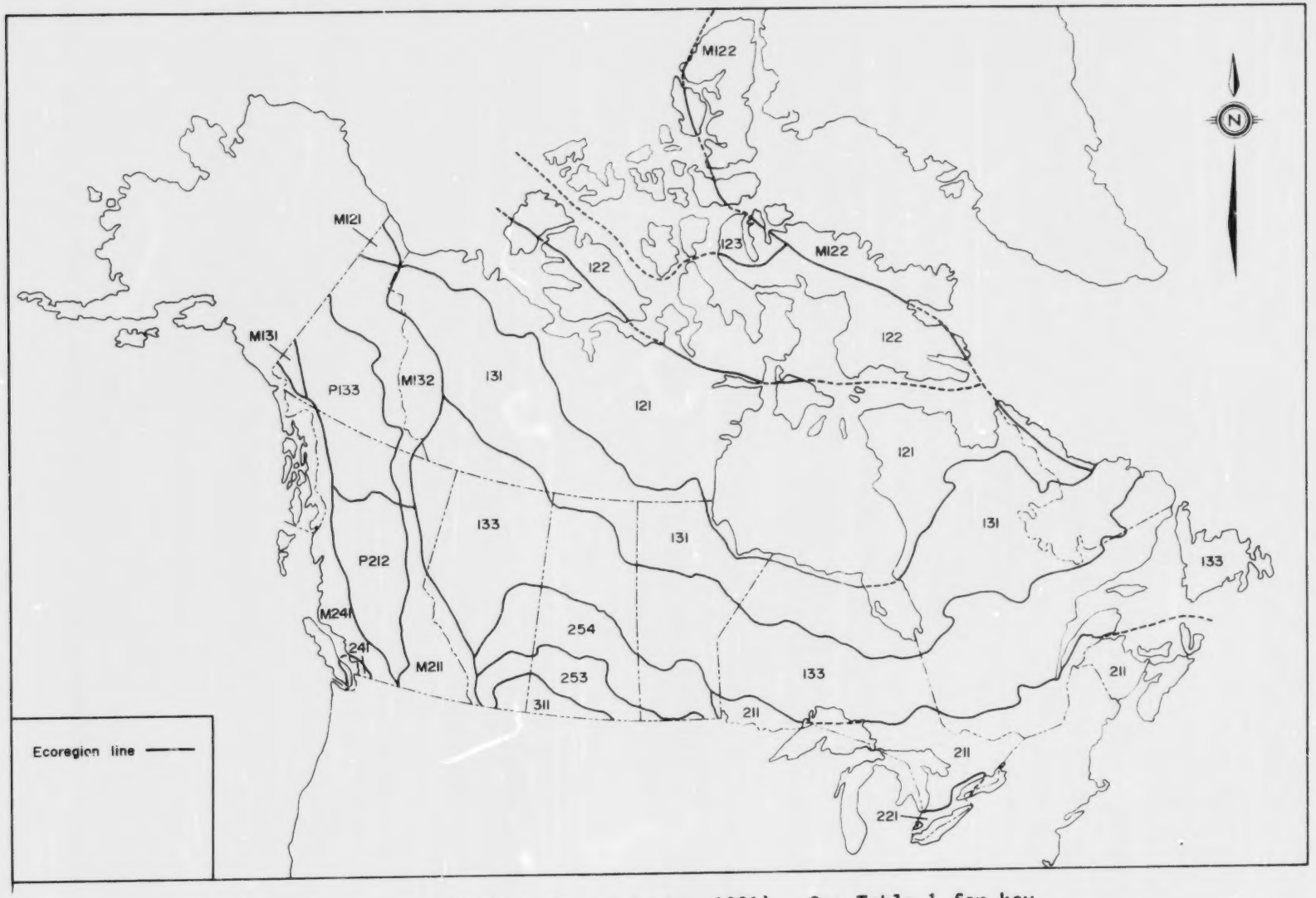


Figure 1. Ecoregions of Canada (Bailey and Cushwa 1981). See Table 1 for key to ecoregion province numbers.

Table 1. Scheme for a third-order ecosystem regionalization of Canada (modified from Bailey and Cushwa 1981)

100 POLAR DOMAIN
- 120 Tundra Division
  - 121 Low Arctic Tundra Province
  - 122 High Arctic Tundra Province
  - 123 Polar Desert Province
- H120 Tundra Regime Highlands
  - M121 Brooks Range Province
  - M122 Northeast Seaboard Mountains Province
- 130 Subarctic Division
  - 131 Subarctic Parkland Province
  - 133 Boreal Forest Province
- H130 Subarctic Regime Highlands
  - M131 Alaska Range Province
  - M132 Subarctic Rockies Province
  - P133 Yukon-Stikine Plateau Province

200 HUMID TEMPERATE DOMAIN
- 210 Humid Warm-Summer Continental Division
  - 211 Laurentian Mixed Forest Province
- H210 Humid Warm-Summer Continental Regime Highlands
  - M211 Columbia Forest Province
  - P212 Fraser-Nechako Plateau Province
- 220 Humid Hot-Summer Continental Division
  - 221 Eastern Deciduous Forest Province
- 240 Humid Maritime Division
  - 241 Willamette-Puget Forest Province
- H240 Humid Maritime Regime Highlands
  - M241 Pacific Forest Province
- 250 Subhumid Prairie Division
  - 253 Tall-Grass Prairie Province
  - 254 Aspen Parkland Province

300 DRY DOMAIN
- 310 Semiarid Steppe Division
  - 311 Great Plains Short-Grass Prairie Province

toward nonconsumptive wildlife use; one recent survey of public attitudes found the species group ranking the highest in interest was songbirds and gamebirds (higher than ungulates such as mule deer) (Self 1982).

The responsibility for management of the habitat (i.e. lands and vegetation) is divided between the Ministries of Lands, Parks and Housing and of Forests. These two provincial Ministries have this mandate over most of the provincially owned land base (about 93 percent of British Columbia). The former Ministry has a primary orientation towards single land use. The latter Ministry has the major role in multiple resource decisions affecting land use. The primary goal of the Ministry of Forests is "to realize the maximum contribution of available forest and range resources, now and in the future toward the social and economic well being of British Columbia" (B. C. Ministry of Forests, Information Services Branch 1980a). The planning process to achieve this goal is based on Section 4 of the Ministry of Forests Act of 1978 (R.S.B.C. Chapter 272) that states in part that other natural resource values such as fish and wildlife must be coordinated and integrated with the use of these forest and range resources.

1.3 The Need

Wildlife managers have two different opportunities to manage wildlife habitat. The first is to manage habitats themselves by such techniques as manipulating vegetation and controlling water levels. This approach is important but also costly, time consuming, and consequently geographically very limited. The second opportunity is to indirectly manage habitats by working with other resource managers to achieve the best mix of mutual goals through the modification of their activities for the benefit of wildlife. Although this important approach currently tends to be slow, reactive, and costly, it has enormous potential. Thomas (1979a:13) suggests that "timber management is wildlife management" and "the degree to which it is good wildlife management depends on how well the wildlife biologist can explain the relationship of wildlife to habitat and how well the forester can manipulate habitat to achieve wildlife goals".

In British Columbia, most habitat manipulation is done by silvicultural or range management activities. There is a strong legislated premise that productive forest land will be managed with wood fibre as a primary product. Telfer and Dauphine (1981) suggest there is "a lack of policy guidelines for the minimum wildlife community that should persist during and following

forestry operations" that puts wildlife managers at a disadvantage in competing with forestry interests. However, there is also a legislated mandate for multiple resource integration that allows for wildlife resources to be optimized within the context of overall resource management. Managing commercial tree species in a cost-effective manner can also result in present and future wildlife habitat needs being met or enhanced to the extent practicable under this decision. It will be the effectiveness of integration and coordination between wildlife and timber and range management that will determine whether or not our joint management activities will meet the wildlife aspects of multiple use resource objectives. Fortunately, there is a growing trend towards improved cooperation and integration of objectives of fish and wildlife. This trend is leading to a more holistic view of forest management, emphasizing land management rather than simply timber or forage management.

Three present weaknesses inhibit integrated philosophy of management:

1) emphasis has been on the few game species;
2) information on wildlife species and their relationships with habitat is widely scattered and poorly understood for many species; and
3) this information is not readily available to land managers in a system that they can use to predict the impact of their management activities on wildlife; either they must depend upon personal interaction with professional biologists, or omit impact assessment.

The need for organization (i.e. in handbook form) of this information and knowledge to "develop a common understanding among resource specialists about wildlife habitats in managed forests [and rangelands]" and to "provide a system to predict the impact of forest [and range] management practices on wildlife" (Thomas 1979a:11) is based on five primary factors in British Columbia:

1) high ecological diversity (flora and fauna);
2) rapid rate of habitat change through land management practices;
3) split responsibility for management of habitat and wildlife;
4) demand for increasing richness of wildlife species;
5) most terrestrial vertebrates use forests.

Each of these factors is insufficient justification for the handbook but in combination, they argue strongly for the preparation of a habitat handbook.

1.4 The Solution

A promising solution to the knowledge problem is found in the "handbook" products being produced in the wildlife fish habitat relationships program in the National Forests of the United States (Nelson and Salwasser 1982). The best known example is J. W. Thomas' (1979c) handbook entitled Wildlife Habitats in Managed Forests: the Blue Mountains of Oregon and Washington. The core of this program is the organization of relevant knowledge on life history characteristics for all vertebrate wildlife species found in an area in a readable, understandable format, coupled with information on the relative capabilities of different environments or habitats to support wildlife. The key concept of these handbooks is that they strive to synthesize the best existing knowledge on habitat requirements of species and how forest or range activities affect these needs. This knowledge is used to predict the probable consequences of contemplated forest or range management on wildlife : handbooks do not give rigid guidelines. The wildlife or forest/range manager analyses the effects of proposed activities on wildlife species and on wildlife management objectives, and then recommends the most appropriate course of action. The assumption of this approach is that by providing suitable tools to the resource managers, wildlife aspects of the environmental assessment process will be improved. This approach will help administrators understand wildlife opportunities and assess more fully the consequences of their decisions.

1.5 Goal of the Wildlife Habitat Handbook Program

The primary goal of the British Columbia wildlife habitat handbook program is:

> to provide the managers with the capability to make better analyses and decisions in meeting objectives for wildlife diversity and abundance through the application of species-habitat relationships to coordinated and integrated forest and rangeland planning and management.

This goal follows directly from existing legislation and policies of the Ministries of Environment and Forests.

1.6 Program Organization

The wildlife habitat handbook project is part of a program called "The Development of Wildlife Habitat Handbooks for the Forest and Rangelands of British Columbia and Associated Projects". The program goal is to develop planning tools that aid wildlife habitat management in British Columbia. A memorandum of agreement has been signed by the program participants, who are:

Ministry of Forests, Research Branch

Ministry of Environment, Fish and Wildlife Branch

Ministry of Environment, Surveys and Resource Mapping Branch

Ministry of Provincial Secretary and Government Services, Provincial Museum Branch

University of British Columbia, Forestry Faculty

This memorandum (see Appendix 11.1) includes terms of reference for the Handbook Coordinating Committee and for the responsibilities of the participants. At the time of the writing of this problem analysis, committee members are: R. Ellis and B. Nyberg (MOF); D. Eastman, B. Pendergast and R. Silver (MOE); W. Campbell (MPS); F. Bunnell (UBC); and A. Harestad (SFU). This committee has produced a project proposal (see Appendix 11.2) that provides broad objectives and procedures, budget, and expected project benefits.

The Kamloops area was chosen for a pilot project and A. Harcombe was assigned as the project coordinator. The direction of the project involves cooperation among groups with an interest in wildlife habitat; many participants not formally on the committee are contributing time and input (see Appendix 11.3). A regional committee will be formed, primarily with the responsibility of producing the handbook. Subcommittees may be formed to produce planned project components. This system should be replicated as the project goes to other regions of the proposed complete provincial coverage.

2 OBJECTIVES

The objectives of this problem analysis are to:

1) review the existing legislation, policies and practices related to planning and management of wildlife and wildlife habitat in British Columbia;
2) analyse the performance of wildlife planning and management by examining the strengths and weaknesses of existing legislation, policies and practices;
3) describe legislation and policies related to planning and management of wildlife and wildlife habitat in the National Forests of the United States;
4) summarize the wildlife fish habitat relationships (WFHR) program developed to satisfy the existing legislation and policies described in objective 3;
5) describe the products of the WFHR program, including species narratives, species/habitat models, and data base organizations;
6) compare the implementation environment of the United States with that in British Columbia;
7) to evaluate the WFHR approach (= habitat handbook) as it applies to conditions and needs in British Columbia;
8) recommend a general framework for a British Columbian habitat handbook project, including the strategy of production and description of the products;
9) recommend a general strategy of implementation of the habitat handbook program in British Columbia.

3 REVIEW OF LEGISLATION, GOALS AND POLICIES

3.1 Organization of Agencies

3.1.1 Ministry of Environment

The Ministry of Environment is structured with a headquarters in Victoria and eight regional organizations (Figure 2). Victoria is concerned primarily with planning and policy making, while much of the responsibility of actual implementation of these policies and plans is decentralized to the various regions (B. C. Public Service Commission, Staff Development and Safety Programs 1981a). Three Victoria branches have a direct influence on wildlife and wildlife habitat. The Surveys and Resource Mapping Branch[1] is involved with ungulate capability mapping, estuary habitat mapping and input into some wildlife habitat projects. The Assessment and Planning Branch coordinates the production of various regional strategic plans. The Fish and Wildlife Branch is involved in setting provincial policies and procedures, in the production of provincial level wildlife plans, in coordinating wildlife and habitat research, and in liaison with other government agencies.

Each region has a Fish and Wildlife group under the direction of a Regional Manager. The regional group has three major functions: wildlife management, fisheries management, and habitat management. There is often a blurring of the roles of the management and protection biologist, especially as they relate to habitat management (Dick et al. 1977). The regional wildlife biologist generally deals with aspects of animal behavior, population dynamics, and habitat utilization, while the habitat management (or protection) biologist uses this information in assessing impacts on wildlife habitat in resource planning programs and in the referral process (see Section 3.4). However, this clear functional division rarely exists (Dick et al. 1977), which can lead to a dispersed, fragmented approach to habitat-related management activities.

Other than the region, the only formal geographic subdivisions are the districts and management units (MU's) (B. C. Ministry of Environment, Fish and Wildlife Branch 1982a). Districts are subregional areas for enforcement purposes. Management units are used for the purpose of defining the open hunting seasons for big game, small game and game birds of the Province (Figure 3). The management unit is designated numerically within the administration region

---

[1]prior to September, 1982, this comprised two branches - Surveys and Mapping Branch and Terrestrial Studies Branch.

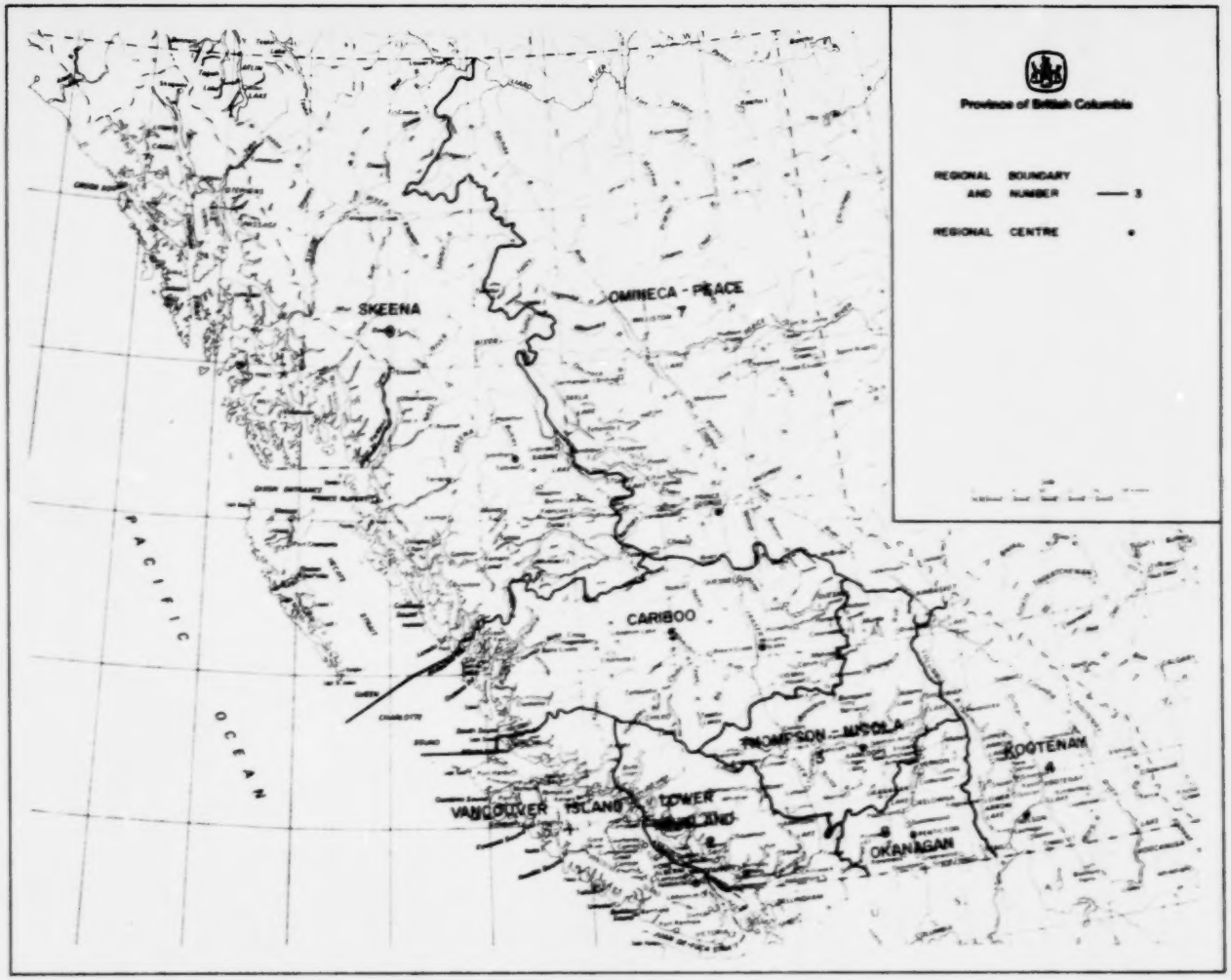


Figure 2. Wildlife administrative regions in British Columbia (Drawn by Surveys and Resource Mapping Branch, B. C. Ministry of Environment 1981).

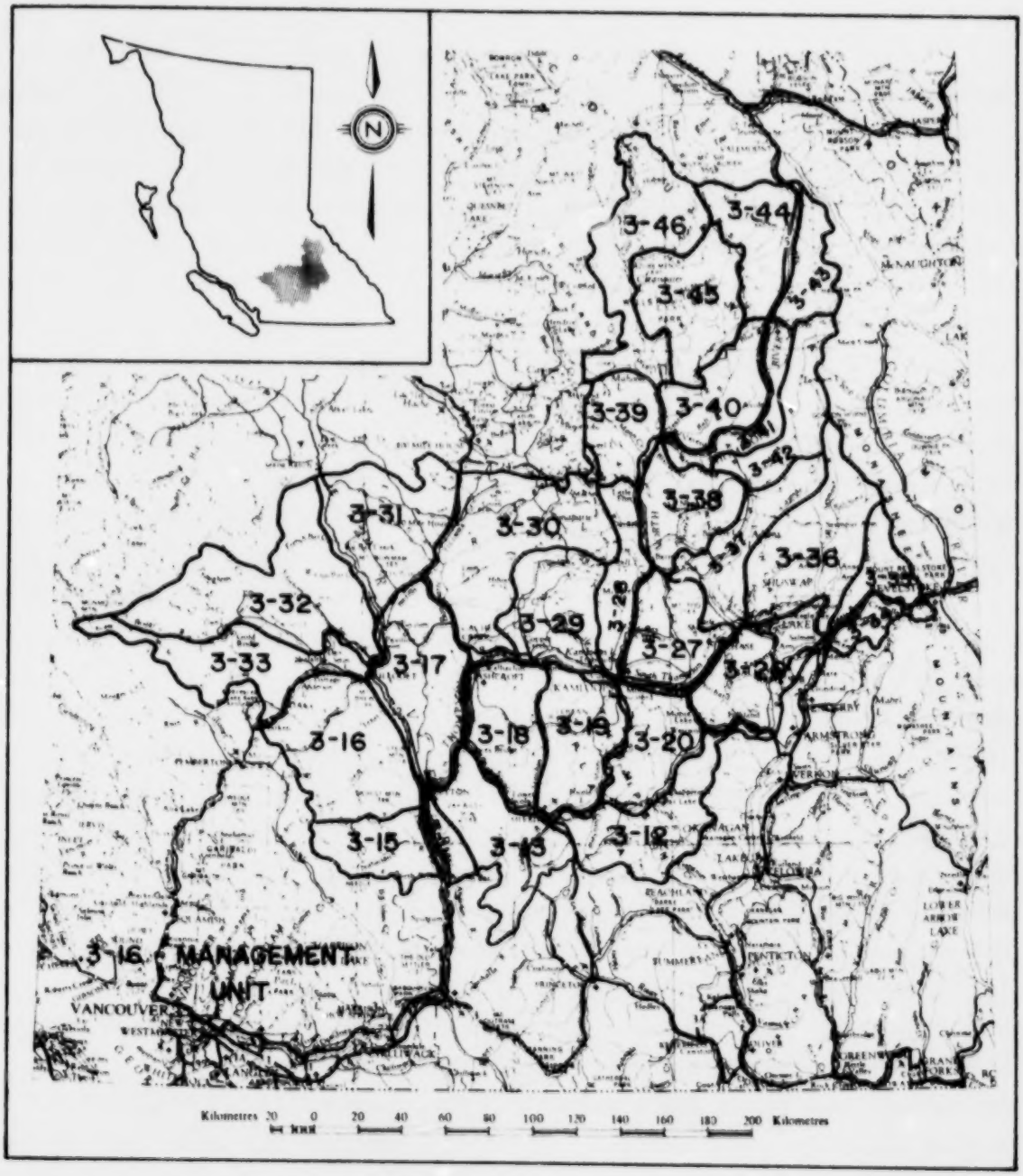


Figure 3. Management units of the Thompson-Nicola region (from B. C. Ministry of Environment, Fish and Wildlife Branch 1982a).

(e.g. MU 3-16: unit 16 in region 3 [Thompson - Nicola]). These units are sometimes used for inventorying animal populations (R. Ritcey, pers. comm.).

3.1.2 Ministry of Forests

The Ministry of Forests is structured administratively into three levels - headquarters, regions, and districts. The headquarters' functions involve developing and monitoring of policy and programs under the Ministry mandate. Six regions (Figure 4) are authorized to interpret Ministry programs and policy and to establish guidelines and priorities to meet the set program goals (B. C. Ministry of Forests, Information Services Branch 1980c). The regions monitor and evaluate the performance within districts. They are responsible for the consistent, effective administration of policies, procedures and plans originating from headquarters, as well as developing regional plans and programs for the management of forest, range, and recreation resources (B.C. Public Service Commission, Staff Development and Safety Programs 1981b). The region is also responsible for directing, coordinating, and monitoring all field operations conducted in the Region, and for maintaining a continuous inventory of all regional forest and range resources.

Districts are subdivisions of regions (five to nine per region) with an organizational structure designed to implement programs and policies in accordance with regional guidelines and local procedures (B. C. Ministry of Forests, Information Services Branch 1980c). The district office has the task of putting Ministry policy into actual practice in the field. The district processes and administers all applications for the various types of permits and licenses for resource harvesting; it also processes all proposed logging and development plans (B.C. Public Service Commission, Staff Development and Safety Programs 1981b). Each district is supervised by a district manager. Under the manager may be two operational superintendents who split the responsibilities for protection, range, inventory, recreation, engineering, timber, and silviculture. Each district may have different splits in responsibility with different emphases dependent upon district resources.

Within each region are a number of Timber Supply Areas (TSA's)(revision of Public Sustained Yield Units). These are geographical units defined for harvesting, planning and regulation (B. C. Ministry of Forests, Information Services Branch 1980a). Districts may be geographically equivalent to or subdivisions of Timber Supply Areas (see Figure 5), except TSA's do not include

Figure 4. Administrative forest regions of the B. C. Ministry of Forests (from B. C. Ministry of Forests, Information Services Branch 1980c).

Figure 5. Proposed Timber Supply Areas of British Columbia (modified from B.C. Ministry of Forests, Information Services Branch 1980c)

the larger provincial parks. TSA's are used as the primary level of inventory and supply projection.

3.1.3 Ministry of Lands, Parks and Housing

The Ministry of Lands, Parks and Housing has five major divisions (B. C. Public Service Commission, Staff Development and Safety Programs 1981c). One of the headquarter divisions, the Lands Division, includes the Ecological Reserves Unit, which establishes and administers Ecological Reserves, and the Land Programs Branch, which provides planning and policy direction for the best use and allocation of Crown land (except provincial forests). The Lands and Housing Regional Division operates through eight regional and nineteen district offices to provide province-wide service relating to lands and housing (Figure 6). This division plans, manages, allocates, develops and markets Crown land. Each district has a land manager who provides the recommendation of matters dealing with Crown land for regional manager approval. The Parks and Outdoor Recreation Division is also represented at a regional level, with responsibility for planning and establishing a system of parks and recreation areas.

3.2 Legislation

3.2.1 Introduction

A number of Provincial Acts refer to either wildlife or wildlife habitat, with varying degrees of implication for wildlife management. As well, although some provincial ministries do not have legislation specific to wildlife and habitat, they have certain influencing policies or goals. This section deals with the former cases; policies are described in the subsequent Section (3.3). A discussion of the strengths and weaknesses of the existing legislation is included in Section 3.2.6.

3.2.2 Ministry of Environment Legislation

The Ministry of Environment has two Acts with implications for wildlife management. The Ministry has the mandate to manage and protect wildlife populations through its administration of the Wildlife Act of 1982 (S.B.C. chap. 57). This new Act provides protection for all native wildlife, provides the opportunity for protection of habitat essential to wildlife, provides a means of enhancement of wildlife habitat and allows for the development of integrated resource use plans involving wildlife. The Cabinet may designate Crown land as

Figure 6. Administrative units of B. C. Ministry of Lands and Housing.
(From B.C. Ministry of Environment, Surveys and Mapping Branch 1982)

Wildlife Management Areas and the Minister may further designate such areas as a Critical Wildlife Area of threatened or endangered species or as Wildlife Sanctuaries (Sections 4 and 5). The declaration of wildlife management areas will require resource management plans and agreements by resource agencies.

The Wildlife Act includes two important definitions that will be utilized in this report. Habitat or wildlife habitat "means the air, soil, water, food and cover components of the environment on which wildlife depend directly or indirectly in order to carry out their life processes" (Section 1[1]). Wildlife "means raptors, threatened species, endangered species, game and other species of vertebrates prescribed as wildlife" and may include fish.

The Environment Management Act of 1981 (S.B.C. chap. 14) provides the Minister of Environment with powers to participate in matters relating to management, protection and enhancement of the environment, including preparation of environmental management plans which may include measures with respect to wildlife management and development of policies for management and use of the environment. It is important to note the definition of environment - "includes air, land, water and all other external conditions or influences under which man, animals and plants live or are developed." Provisions of the Environment Management Act allow the Minister to intervene where detrimental environment impacts occur or may occur that substantially reduce the capacity of the environment to support life. Also the Minister may request environmental impact assessments to be done if a detrimental impact is a possible consequence of proposed activities. Both Acts allow the Minister to "acquire" habitat by buying or leasing land.

3.2.3 Ministry of Forests Legislation

Three major Acts deal with forest and range planning and management. These are the Ministry of Forests Act of 1978 (R.S.B.C. chap. 272), the Range Act of 1978 (R.S.B.C. chap. 355) and the Forest Act of 1978 (R.S.B.C. chap. 140). There have been a few relatively minor amendments. The Ministry of Forests has complete management of forest and range resources within provincial forests, and some control over timber on other Crown land and over forage on non-leased Crown land. Provincial forests are defined as Crown land which will provide the greatest contribution to the social and economic welfare of the province if the land is maintained for integrated management of renewable natural resources (B. C. Ministry of Forests, Planning Division 1979). The Ministry of Forests Act states that one of the functions and purposes of the Ministry is, under the direction of the Minister, to:

> "Plan the use of forest and range resources of the Crown so that the production of timber and forage, the harvesting of timber, the grazing of livestock and the realization of fisheries, wildlife, water, outdoor recreation and other natural resources values are co-ordinated and integrated in consultation and co-operation with other Ministries and agencies of the Crown and with the private sector" (Section 4 [c]).

The Forest Act states that "subject to regulations, a Provincial forest shall be managed and used" for several purposes, including "forage production and grazing by livestock and wildlife", and "water, fisheries and wildlife resource purposes" (Section 5.4). This Act also stipulates that the Chief Forester will assess provincial land for a number of potentials, including potential for "producing forage for livestock and wildlife (Section 3 [c]). In the Range Act, the only reference to wildlife management is indirect: a "grazing license shall be consistent with the planned grazing system and any multiple use plan in force at the time the license is entered into for the Crown range over which the license is to apply" (Section 4).

3.2.4 Ministry of Lands, Parks and Housing Legislation

The Land Act of 1979 (R.S.B.C. chap. 214) includes no direct references to wildlife. However, the Minister has the administration of all Crown land except land specifically under the administration of another Minister, such as Provincial forests or parks. This Crown land may be reserved from disposition under the Act for any purpose considered advisable in the public interest. However, except where Crown land is required for agricultural settlement and development or other higher economic use, Crown land that is suitable for production of timber and pulpwood shall not be disposed of by Crown grant under this Act. Section 11 of the Act allows for reserve status for important wildlife areas to be assigned, though a reserve does not imply the disposition of land management responsibility. Section 101 of this Act allows for the transfer, by Order In Council, of administration and control of Crown Land from Lands, Parks and Housing to another Ministry of the Crown. This represents a more secure form of tenure than reserves in that the transfer is for a set time period, usually at least 10 years. Such a transfer is the only basis for the establishment of Wildlife Management Areas on Crown Lands managed by Lands, Parks and Housing.

The Parks Act of 1979 (R.S.B.C. chap. 309) gives the Parks Branch jurisdiction and responsibility for management of all resources in all parks and recreation areas, including "Wildlife and its habitats on and in parks and recreation areas" (Section 3 [1] [c]). Natural resources are protected unless,

in the opinion of the Minister, some form of wildlife management is required for preservation or maintenance of the recreational values of the park. Regulations may provide for such items as fixing the number, age and sex of specific wildlife and designating the period during which wildlife species may be hunted or taken in any park (Section 33 [2] [d and e]).

The Greenbelt Act of 1977 (R.S.B.C. Chap. 36) allows the Minister to acquire, regulate and manage land for the purposes of establishing and preserving greenbelt land. The Minister "may delegate the management of greenbelt land".

The Ecological Reserves Act of 1971 (R.S.B.C. Chap. 16) allows the Minister to reserve Crown land for ecological purposes including "areas in which rare or endangered native plants and animals in their natural habitat may be preserved."

3.2.5. Federal Government Legislation

Most species of migratory birds are protected in Canada under the Migratory Birds Convention Act of 1917. As a result, the Canadian government is "empowered to pass and enforce regulations to protect these species of migratory birds" which are included in the Convention (an agreement made with the United States in 1916) and which inhabit Canada for all or part of the year (Canada Fisheries and Environment, Canadian Wildlife Service 1978). The Convention recognized migratory game birds (ducks, geese, swans, rails, coots, gallinules, cranes, shorebirds, doves and/or pigeon families); migratory insectivorous birds and other migratory non-game birds. Birds not falling under federal jurisdiction (including grouse, pheasants, quail, ptarmigan, hawks, eagles, falcons, owls, cormorants, pelicans, crows and jays and introduced species) can be protected under the provincial Wildlife Act (1982) in British Columbia.

3.2.6. Strengths and Weaknesses of Legislation

The major strength of the Ministry of Forests Act, for wildlife and habitat, is Section 4(c), which acknowledges the need to consider wildlife in planning the use of provincial forest resources. The major weaknesses are the lack of definition of two terms (and maybe the inability to implement the terms) relating to interagency interaction: integration and coordination. Integration may be defined as a land management concept: cooperative management in time and space to meet overall objectives (H. Salwasser, pers.

comm.). Coordination is defined as a planning concept: common scheduling of activities to meet overall objectives and resource standards. These definitions seem to coincide with usage in the U. S. National Forest Management Act of 1976, which requires preparation of integrated management plans for the U. S. National Forests (Mealey and Horn, 1981). The concept of management of a number of renewable resources so they may be utilized in a combination that best satisfies the needs of society (= multiple use) requires a quantitative integration of these multiple uses. Integration as a management objective necessarily requires coordination - both are cooperative ventures. Unlike treatment of Crown land under the Lands Act, there seems to be no simple method to transfer the administration of land (i.e. habitat) in Provincial Forests from the Ministry of Forests to the Ministry of Environment.

In the Wildlife Act, the legal definition of wildlife is probably adequate for the requirements of legal protection of wildlife species, but presently excludes the majority of vertebrate species. This definition is a weakness if other legislation, such as the Ministry of Forests Act, uses the same definition--it would mean that nondesignated species would not have to be considered in the integration/coordination process of planning resource use in Provincial Forests. Therefore, wildlife has a broader definition for the purpose of this habitat handbook program: wildlife will include all free-ranging members of the classes Amphibia, Reptilia, Aves and Mammalia.

The apparent interpretation of "environment" under the Environmental Management Act does not include animals and plants as "external conditions". This means that any action that results in changes in successional status of vegetation in an area, though it may strongly reduce the capacity of the area to support wildlife, is not protected under the Act nor will such action require an impact assessment.

3.3 Goals and Policies of Planning and Management

3.3.1 Introduction

Goals are defined as the general description or statement of the purpose and direction of management. Generally, they should reflect perceived present and future need and be capable of being effectively pursued (B. C. Ministry of Forests, Planning Division 1978; B. C. Ministry of Environment, Fish and Wildlife Branch 1979). Objectives are statements describing specific management intent and direction. They are usually quantified, can be measured over time,

and are the end results capable of being achieved through management at a specified administrative level (B. C. Ministry of Forests, Planning Division 1978; B. C. Ministry of Environment, Fish and Wildlife Branch 1979). Policy is a statement on how the authority is to achieve the goals and objectives and describes the framework within which courses of action are developed to meet these objectives. The following sections will be limited to the two agencies with the greatest impact on wildlife management, the Ministries of Environment and Forests.

3.3.2 Ministry of Environment

The Ministry of Environment has a broad mandate to enhance and maintain a quality habitat for people, fish and wildlife, with an emphasis on both short and long range environment planning (B. C. Public Service Commission, Staff Development and Safety Programs 1981a). Two principal goals of the wildlife management program (B. C. Ministry of Environment 1981) are:

1) to maintain the diversity and viability of species representative of the major biophysical zones of the province, and;
2) to ensure that, within the constraints of land capability and the biological limits of each species, wildlife is available in sufficient abundance to meet the social, recreational, ecological and economic needs of society.

Sixteen objectives are listed for the wildlife management program (B.C. Ministry of Environment [1980?]). Those of special significance to wildlife habitat include:

1) to protect, maintain and enhance wildlife and wildlife habitat in order to achieve population objectives stated in the Wildlife Management Plan for British Columbia (see below);
2) to inventory and/or monitor the wildlife resource to ensure objectives are being met or to ensure options for future benefits are identified;
3) to provide for an analysis of supply capabilities of habitat types for wildlife species to guide the setting of future objectives; and,
4) to cooperatively plan land and resource use to ensure the wildlife management program is compatible with providing maximum environmental, social and economic benefits to society.

In order to help attain some of these goals and objectives, a planning process for wildlife management is being developed. This process has two primary objectives (B. C. Ministry of Environment, Fish and Wildlife Branch 1979):

1) to formulate clear statements in effectively organizing and implementing management activities; and,
2) to communicate to the public the benefits, opportunities, costs and problems involved in managing wildlife in British Columbia.

Several levels of planning are underway: provincial, regional and subregional. The following description of these levels and the types of plans are from Proposed Wildlife Management Plan for British Columbia (B. C. Ministry of Environment, Fish and Wildlife Branch 1979) and from Regional Wildlife Management Plan: Region 3 Thompson/Nicola (B. C. Ministry of Environment, Fish and Wildlife Branch 1982b). Two time frames are incorporated in these plans. The longer time frame or "planning horizon" is a period of twenty years. This period will allow realization of benefits from any wildlife or habitat enhancement activities. The shorter time frame or "management period" will be used to reassess the planning horizon objectives every five years. This five year management period is the longest practical period, given changes in such aspects as land use and public demands. The plans will be reviewed annually by Fish and Wildlife staff (B. C. Ministry of Environment, Fish and Wildlife Branch 1982b).

1) Provincial level plans are of two kinds. The Proposed Wildlife Management Plan for British Columbia (1979) has the primary objective of informing the general public about the provincial government's objectives for managing wildlife in British Columbia and provides a general overall direction and degree of management. Its secondary objective is to set down broad guidelines for program operations. A second level of provincial plans is the set of preliminary species plans consisting of documents, each of which will explain in detail what guided the setting of objectives, policies and management prescriptions for 27 species or group of species in the province.
2) Regional plans, identified as Regional Wildlife Management Plans, consist of eight documents, one for each wildlife administration region in British Columbia (see Figure 3). Each document will focus on the management of wildlife within a particular region by addressing regional management objectives, priorities of work, costing, and operational methodology. Therefore, the plans will form a program

structure for Regional implementation of objectives derived at the Provincial level.

3) Sub-regional Strategic plans (prepared by the Planning and Assessment Branch of the Ministry of Environment) are a description of management objectives for a part of the region for the 20 year planning horizon based on analysis of resource supply and demand for water, waste, air, fish and wildlife. They provide a description of management programs (3-5 years) which reflect priorities established by the regional wildlife plan to accomplish the long term objectives, and they coordinate Ministry activities at the operational level through the development of five year working plans and budgets.

4) Operational plans are the most detailed level of planning conducted by the Ministry. They are implemented on a site-specific basis to meet objectives adopted in the strategic and regional plan. These plans, such as Wildlife Management Area Plans, will be prepared as and where required where the region either actively promotes intensive management of a particular area because of its high wildlife value or has to respond to competing resource uses that threaten a highly valued species or critical habitat (B. C. Ministry of Environment, Fish and Wildlife Branch 1982b).

An example of a regional wildlife management plan is that for Region 3, Thompson/Nicola (B.C. Ministry of Environment, Fish and Wildlife Branch 1982b). Specific regional objectives are:

1) to advise the public of the anticipated benefits, costs and problems associated with the management of wildlife;

2) to state clearly the purpose and direction in setting work priorities, allocating the budget, planning management activities and establishing criteria to evaluate Branch programs;

3) to convey to other resource agencies, other levels of government and private industry how regional management priorities relate to each species and its habitat, for their maintenance, protection and enhancement;

4) to develop a five year plan of operation to implement these objectives;

5) to provide policy directions to wildlife management at the regional level that is consistent with Provincial goals; and,

6) to provide a context for the development of the plans at the strategic and operational plan levels.

A number of policies "guide the stewardship of wildlife in British Columbia" (B. C. Ministry of Environment, Fish and Wildlife Branch 1979:19). Of interest to the management of wildlife are the following:

1) benchmark populations - populations of animals living without interference from man are important as benchmarks, both for measuring the success of wildlife management and in understanding the natural functioning of biological systems. The maintenance of such populations and their habitats will be encouraged within ecological reserves, parks, nature conservancies and wildlife management areas.

2) habitat enhancement - on lands acquired for habitat management that are in a natural or near-natural state, management techniques will be limited to the control or maintenance of a particular stage of ecological succession through the use of thinning, prescribed fire, and domestic grazing. However, if it can be clearly demonstrated that active enhancement will result in a significant increase in productivity and associated benefits, a more comprehensive approach will be used. Lands acquired for habitat management that have been substantially modified by human use will be actively enhanced for the production of designated wildlife species, and managed, where possible, for integrated resource use. Lands under the administration of other agencies will be enhanced when possible where they are managed for integrated resource use. Most species using an area will be given consideration when enhancement is planned.

3) inter-agency cooperation - cooperation of provincial agencies administering or using the land is encouraged. Greater effort must be made to integrate multi-agency planning at an early stage if the resource (vegetation and wildlife) is to be protected or enhancement opportunities realized.

4) inter-government cooperation - close cooperation is practiced with other governments who share jurisdiction over the resource (migratory birds), the habitat, or who have similar management problems. Membership is held in several international associations whose main interest is conservation and wildlife management. Cooperation with local governments, other provinces, and the federal government will be

continued to help solve wildlife problems of local and national interest.

5) priorities for work - to obtain the best results from available funds and staff time it is necessary to set priorities for work. Species have been grouped into priority categories for the province based on the goals of wildlife management, some appreciation of public demand, and the need for public safety. Priorities in the eight regions may differ depending on the presence or absence of certain species and on public demand.

The listing in Table 2 is not the final word. While threatened and endangered species are being protected work on other species groups must continue. Work will be generally directed to species and areas where the most effective return on management dollars is realized, based on demonstrated public use and public safety.

Table 2. Priority categories of wildlife species groups for British Columbia[a]

Priority	Species Groups
1	Endangered or threatened species
2	Moose, deer, elk, caribou
3	Sheep, goat, bear
4	Raptors (hawks and other carnivorous birds), wolf, cougar
5	Waterfowl, furbearers, upland game bird
6	Nongame birds and mammals, reptiles, amphibians

[a]Source: Proposed Wildlife Management Plan for British Columbia (1979). Fish and Wildlife Branch, B. C. Ministry of Environment, Victoria, B. C. p. 24.

3.3.3 Weaknesses of the Goals and Policies of the Ministry of Environment

The major roadblock in the way of achieving wildlife management goals is that the majority of interaction of wildlife and habitat occurs on unalienated Crown land. More than ninety percent of this land base is administered and managed by the Ministry of Forests for timber or range use (B.C. Ministry of Forests, Information Services Branch 1980c). Because only a small fraction of Crown land is in Wildlife Management Areas (less than 1 percent) Crown lands

"may offer less secure, time-limited protection under agreements that will see the land administered on a cooperative basis for wildlife" (B.C. Ministry of Environment 1981). On the majority of Crown land, the "degree and quality of inter-agency cooperation will ... be the major factor determining the success of efforts to ... manage wildlife" (B. C. Ministry of Environment 1981). In order for the Ministry of Environment to have any control over land for wildlife management purposes, they have to negotiate with the appropriate government agency. Established inter-agency channels are used for obtaining cooperation and implementing management plans (B. C. Ministry of Environment, Fish and Wildlife Branch 1982b). Though this is a reflection of present government priorities for use of Crown land, it can be considered a weakness in terms of achieving stated wildlife goals.

Several constraints to achievement of wildlife management objectives are listed in the preliminary wildlife management plan (B. C. Ministry of Environment, Fish and Wildlife Branch 1979). Of importance to this report are:

1) outside influences - development may significantly alter amounts of wildlife habitat by encroachment and alienation;
2) lack of technical knowledge may delay attainment of some species objectives, so measures taken to accommodate the requirements of those species in habitat management programs or coordinated resource management plans may be inadequate; and,
3) government policies effect the status of wildlife by altering the type or extent of land use.

Many of the basic concepts considered in the existing legislation and program goals are <u>not</u> clearly defined. This leads to ambiguity in interpretation and poor understanding of intent. The concepts of integration, coordination, and multiple use have been briefly discussed (see 3.2.6). Wildlife, habitat and environment have already been defined within the appropriate legislation (see 3.2.2). The wildlife management program goals contain several concepts that are not defined within the accompanying discussion paper. These, discussed below, include diversity, viability, land capability, biophysical zones, and sufficient abundance.

3.3.3.1 Diversity

As identified in the first British Columbia wildlife management goal (page 23), diversity is a critical concept in the present management system. Unfortunately, the concept has not been defined or expanded, nor has it been

projected into management plans as specific objectives. Much effort has been directed in the United States towards diversity, after the term was used in federal legislation. Many of the following thoughts have been extracted from ongoing American projects and policies.

Diversity is defined in the Random House College Dictionary (Stein 1975) as "unlikeness; the state of being diverse" or "variety, multiformity." Diversity relates to biological variety that encompasses four major elements: 1) biotic or species and community richness (both plants and animals); 2) physical richness (soils, topography, water, dead vegetation, etc.); 3) evenness (relative abundance of richness elements); and 4) pattern (distribution, shape, and juxtaposition of richness elements). Siderits and Radtke (1977) have defined diversity as "a variety of plant and wildlife communities within a given area", and they acknowledge that all components of the ecosystem need to be evaluated in land management.

Odum (1971), in a discussion related to succession, identifies four ecosystem attributes: 1) species diversity - variety component (species richness); 2) species diversity - equitability component (evenness); 3) biochemical diversity (organic compounds); and 4) stratification and spatial heterogeneity (pattern diversity). Trends from low to high for the first three attributes and from poorly to well organized for the fourth are expected as succession goes from early seral to climax stages. Odum also discusses the possibilities of a cause-and-effect relationship between diversity and stability. If biotic diversity does enhance physical stability in the ecosystem or is a result of it, the preservation of the biotic variety in man's landscape would "be justified on scientific as well as esthetic grounds" (Odum 1971:256).

Samson and Knopf (1982) describe three different types of diversity: alpha, beta, and gamma. Species richness is considered to be of primary importance to the concept of alpha diversity, along with equitability or evenness with which importance is distributed among species. Alpha diversity is measured by an estimate of the number of species within a habitat, with each species weighted by its abundance. Beta diversity is a concept relating to the amount of species turnover between habitat types or the change of species composition along environmental gradients. An increase in beta diversity "is attributable to an increase in ecological distance between samples drawn from two communities" (Samson and Knopf 1982); a number of different calculations of the difference is possible, including similarity coefficients and Euclidean

distance. Gamma diversity is the total number of species to be found in all the available habitats of a fairly large geographic area (Whittaker 1970). Samson and Knopf (1982) review the concept of alpha diversity, pointing out at least four flaws:

1) relationship of increasing structural diversity causing increased species diversity does not hold in all forest communities;
2) differences attributable to the increase in species number with increasing area are ignored;
3) diversity of breeding populations between consecutive years may reflect events during the nonbreeding season;
4) emphasis on alpha diversity in habitat management favours "edge" species (common and widespread).

Most measures of alpha diversity "ignore the spatial distribution of individuals and the composition dynamics of communities" (Samson and Knopf 1982). It is probably more important to consider beta and gamma diversity.

Diversity as used in the present goal of wildlife management implies diversity of species. It should not imply a mere measurement of selected aspects of biotic variety presented in the form of a mathematical index. Management for diversity should be thought of as management for species richness (Odum 1971; Siderits and Radtke 1977; Thomas 1979a). Management under this concept recognizes wildlife on a community basis, with a wildlife program established to provide a desirable mixture of various habitat components that "will provide the greatest diversity (variety of plant and wildlife communities) through time and space on a sustained basis "(Siderits and Radtke 1977:426). Management for species richness is management to maintain viable populations of all existing native vertebrates in the particular management area (Thomas 1979a), in contrast to management for featured species of special interest (e.g. big game species; endangered and threatened species).

Samson and Knopf (1982:428) suggest three directions for further wildlife management that could be considered as a diversity ethic:

1) "minimize practices promoting site-specific diversity",
2) "emphasize between-habitat diversity at the management unit level", and,
3) "implement a 'top down' or gamma-beta-alpha diversity approach at the regional/rational decision-making levels". They conclude by suggesting that "the extent to which diversity and its applications are

developed in the next few years will play a major role in preserving North American and worldwide biotic diversity".

3.3.3.2 Viability

Viability is a closely connected concept to diversity - the provision of habitat diversity will help maintain viable populations of all vertebrates and will help maintain and improve habitat of featured species (Mealey and Horn 1981). Salwasser and Unkel (1981) define a viable population as being "capable of existing and functioning as an independent unit on a specified area ... over a specified time ... under the set of environmental conditions anticipated (whether they be natural or man-influenced)". The way the term is used in British Columbia may be interpreted in two ways: in a general sense for all species, as addressed through diversity and in a specific sense, related to species in danger of being endangered by habitat changes. Salwasser and Unkel (1981) describe viability as being a function of six principal factors: population size and density, reproductive potential, dispersal capability, competitive ability, habitat conditions (including unit size, unit heterogeneity, stand capability and resilience, and unit interspersion) and effective breeding pairs.

3.3.3.3 Capability

Land capability should not be confused with land suitability. Capability is an assessment of the inherent potential of a piece of land to produce a set of products, such as wildlife, whereas suitability is an assessment of the land in its present stage to produce those products; it may or may not be at its highest potential capability. Objectives for diversity management can reasonably be met by identifying and enhancing the plant community richness (i.e. vegetative diversity) within the bounds of capability. In practical terms, it is suggested that management provides at least the diversity that would be expected in the natural ecosystem (U.S. Department of Agriculture, Forest Service 1982a).

3.3.3.4 Biophysical Zones

The term "biophysical zones" has not been defined or referenced within the provincial wildlife management plan. Historically, this term in British Columbia is connected to the biophyiscal classification program of the Ministry of Environment, arising initially from the Canada Land Inventory and the

British Columbia Land Inventory (van Barneveld 1976). The biophysical (vegetation) zone, a subdivision of a biophysical vegetation region, is a specified classification unit that represents a geographical area in which the dominant vegetation of climax stands on similar soils and terrain is identical (Harcombe 1981a). This classification is described elsewhere in greater detail (Walmsley and van Barneveld 1977; Stevenson 1982). Also, the term has been used in a federal ecological program, as well as in the more general sense to describe major ecologically significant units defined on the basis of biological and physical attributes; these are not tied directly to any specific classification system.

3.3.3.5 Sufficient Abundance

The phrase "sufficient abundance" may be interpreted within the framework of the two previously discussed management strategies - either enough to maintain a viable population of all existing native vertebrates or enough to satisfy the objectives for featured species. The species richness management requires that "the highest possible number of resident species be maintained in viable numbers" whereas featured species management requires "the production of desired species ... in appropriate locations and numbers" (Mealey and Horn 1981). The latter strategy is concerned more with the social, recreational, and economic needs of society, whereas the first strategy for richness is the baseline level based on ecological capability.

3.3.3.6 Conclusions

Under the present planning objectives for species management, the plans have as a target a given number of animals of a species. A more appropriate objective for diversity would be a "given acreage of quality environment that would support a variety of species in different densities, dependent upon the inherent capability of the area" (Siderits and Radtke 1977).

Existing British Columbia Forest Service legislation clearly identifies the importance of including the various renewable resources in multiple use management. Neither goal of the wildlife management program mentions directly the need to integrate wildlife goals with overall multiple use objectives. To achieve diversity goals in reality, the constraints dictated by this integration must be taken into account. Diversity should reflect variety and productivity of both the land and its resources, to be maintained in the context of the land's capability for production.

3.3.4 Ministry of Forests

The Ministry of Forests manages forests and range, and the recreational resource, on lands under its jurisdiction. The Ministry has a goal "to realize the maximum contribution of available forest and range resources, now and in the future, toward the social and economic well-being of British Columbia" (B. C. Ministry of Forests, Information Services Branch 1980a:4). For the purpose of discussing provincial objectives and goals, three main programs have been delineated: timber management, range management and recreational management. Of primary impact on wildlife habitat are the first two programs. The program goals for timber management (B. C. Ministry of Forests, Information Services Branch 1980a) are:

1) to protect and maintain the productive capacity of the forest land base.
2) to produce timber in a cost-effective manner in order to encourage a vigorous, efficient, and world-competitive forest industry.
3) to achieve levels of timber utilization that reflect effective use of the forest resources.
4) to coordinate and integrate Crown timber programs with other programs of the Ministry.
5) to cooperate in the coordination and integration of Ministry timber programs with the programs of other Ministries and agencies of the Crown and with the private sector.
6) to assert the financial interest of the Crown in forest resources and forest management in a systematic and equitable manner.

The program goals for range management (B. C. Ministry of Forests, Information Services Branch 1980a) are:

1) to protect and maintain the productive capacity of the rangeland base.
2) to make Crown range available to the ranching industry, subject to approved range programs, to supplement private forage supplies.
3) to coordinate and integrate Crown range programs with other programs of the Ministry.
4) to cooperate in the coordination and integration of Ministry range programs with the programs of other Ministries and agencies of the Crown and with the private sector.
5) to assert the financial interest of the Crown in range resources and range management in a systematic and equitable manner.

In order to help attain some of these goals and objectives, a planning process is being developed. This process is a logical consequence of Section 4, Ministry of Forests Act (1978), that states that other natural resource values must be coordinated and integrated with the use of forest and range resources. Planning attempts to "adjust forest and range management programs to achieve the desired mix of forest uses" (B. C. Ministry of Forests, Planning Division 1978). Though input is received from other resource ministries and from the public, the Planning Handbook (B. C. Ministry of Forests, Planning Division 1978) states that "it should not be inferred that the end result of the process is a comprehensive land use plan." The Forest Service "does not assume the responsibility for managing anything other than the timber, forage, and recreation resources as defined within the Ministry of Forests Act [1978]" (B.C. Ministry of Forests, Planning Division 1978). The planning must incorporate economic and social criteria as well as resource capability. The Forest Service takes the lead role in planning on all land under its jurisdiction.

There is a hierarchy of planning levels illustrated in Figure 7. The following description is a summary from the Forest Planning Handbook (B. C. Ministry of Forests, Planning Division 1978). At the provincial level, planning is basically in the form of broad policy statements, determined by government with technical assistance from the Forest Service and from liaison with other agencies. Some goals at the provincial level are:

1) to ensure provincial forest resources will be used efficiently to meet provincial policies for natural resource use;
2) to set policies concerning the provincial wood supply;
3) to adjust forest policy in response to changes in supply and demand projections; and,
4) to establish priorities for the integrated use of forest and range resources.

At the regional level, planning incorporates regional differences and recommends timber and forage production goals for the region[1]. Planning is "concerned with policies and strategies to achieve government development

---

[1]British Columbia is divided into six forest regions, administrative units authorized to interpret Ministry programs and policy and to establish guidelines and priorities to meet set program goals (Figure 4).

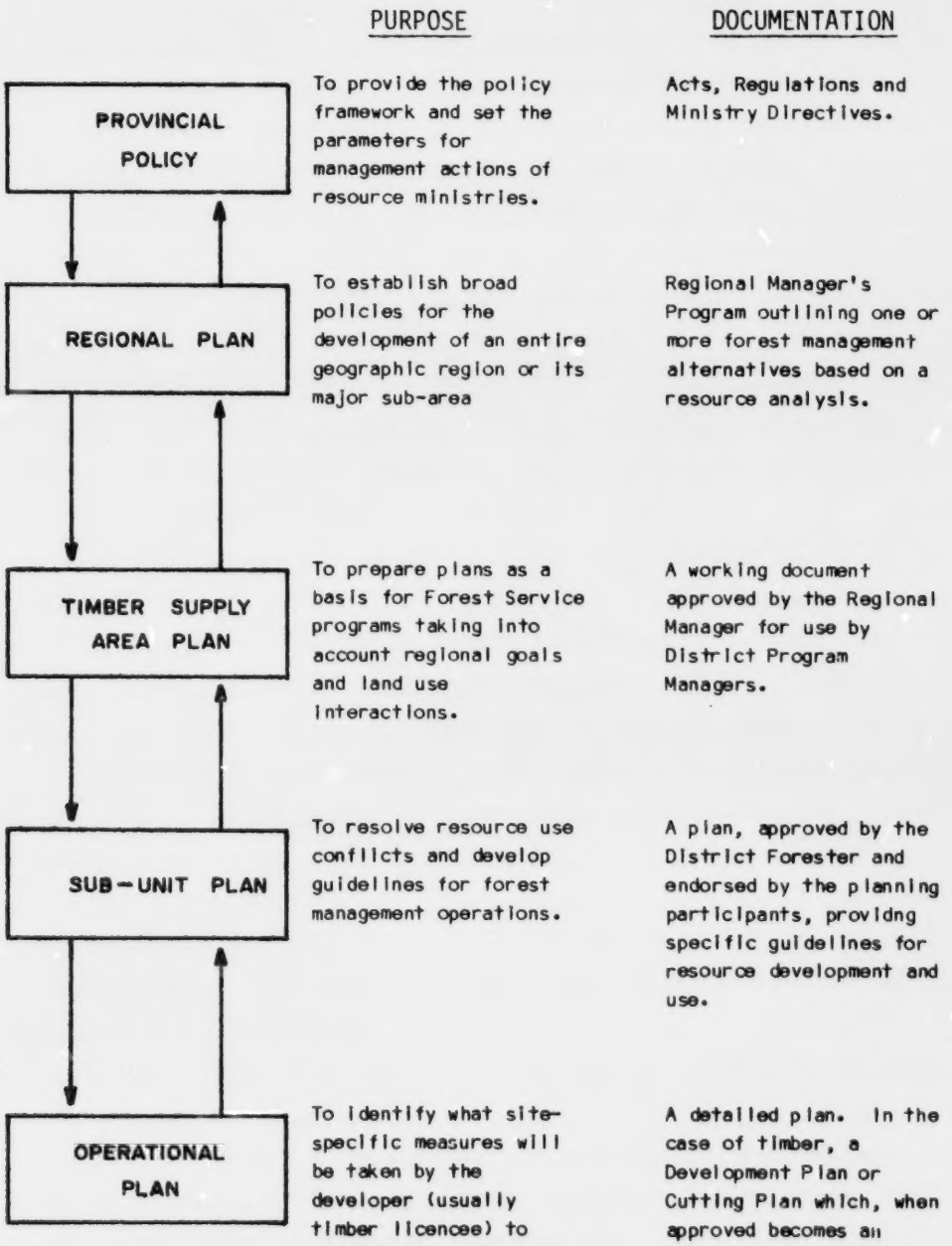

PURPOSE
DOCUMENTATION
PROVINCIAL POLICY
To provide the policy framework and set the parameters for management actions of resource ministries.
Acts, Regulations and Ministry Directives.
REGIONAL PLAN
To establish broad policies for the development of an entire geographic region or its major sub-area
Regional Manager's Program outlining one or more forest management alternatives based on a resource analysis.
TIMBER SUPPLY AREA PLAN
To prepare plans as a basis for Forest Service programs taking into account regional goals and land use interactions.
A working document approved by the Regional Manager for use by District Program Managers.
SUB-UNIT PLAN
To resolve resource use conflicts and develop guidelines for forest management operations.
A plan, approved by the District Forester and endorsed by the planning participants, providng specific guidelines for resource development and use.
OPERATIONAL PLAN
To identify what site-specific measures will be taken by the developer (usually timber licencee) to achieve resource management objectives.
A detailed plan. In the case of timber, a Development Plan or Cutting Plan which, when approved becomes an integral part of the license document.

Figure 7. Hierarchy of planning levels in the B.C. Ministry of Forests (modified from B.C. Ministry of Forests, Planning Division 1978).

objectives" (B. C. Ministry of Forests, Planning Division 1978). Specific regional planning goals are:

1) to establish timber, range and recreation objectives for the region, and;
2) to reconcile Forest Service production goals with the goals for other natural resource agencies.

The regional plans include an analysis of timber supply and demand, an evaluation of other agencies' programs to determine their effect on timber production and a description of planned range and recreation developments.

At the Timber Supply Area (TSA) - Crown land designated within Forest Regions that are geographic units defined for harvest planning and regulation (see Figure 5). Major factors addressed in defining TSA boundaries are locations of manufacturing centers and transportation routes, and available timber supply (B. C. Ministry of Forests, Information Services Branch 1980b) (TSA) level, planning is concerned with the size of the resource base; location is still only expressed in general terms. Specific timber supply area planning goals are:

1) to regulate the rate of timber harvest in conjunction with other land uses and the regional wood flow picture;
2) to ensure efficient and orderly timber harvesting, and;
3) to establish priorities and directions for sub-unit planning.

The timber supply area plans will include sufficient detail to indicate harvesting area and methods, transportation networks, integrated use programs, industrial structure, silvicultural requirements, and forest protection considerations.

A major function of the TSA plan is to identify or anticipate external influences such as other government programs that will influence how the Forest Service carries out its responsibilities. Relationships between timber supply and nonrange or timber uses of forest land must be determined. In practical terms, a major consideration at the planning level is the amount of timber that can be made available to different sectors of the industry. At this level, "other use" constraints may "net down" the available timber or range inventory. Because logging and subsequent silvicultural treatments will create the most significant effects on the forest environment, emphasis must be given to assessing the impact of timber harvesting on other use programs. Of prime importance to this assessment is the consideration of impacts to wildlife created by road access to timber extraction; several B.C. studies indicate

these roads have profound impact on the wildlife resource (F. Bunnell, pers. comm.).

At the sub-unit[1] level, planning ensures achievement of integrated use and timber production objectives. Location of resources becomes important. The sub-unit level planning goals are:

1) to refine timber volumes by species, quality and operability classes;
2) to identify areas critical to soil stability, wildlife, fish, water uses and regimes, stream stability and recreation;
3) to assemble landform and soil data, timber type, site class, and topographic data;
4) to provide a general road layout, indicate logging priorities and cut block pattern;
5) to indicate areas that require special management measures or which are critical for road location (e.g. bridge sites and control points);
6) to indicate how this area will contribute to the annual cut for the management unit.

The designated purpose of the sub-unit plan is to resolve resource use conflicts and direct the operational planner by providing management for each resource or land use and courses of action that are expected to achieve integrated management objectives. Highest priority for the level of planning is placed on areas with complex resource management issues.

At the operational level, planning provides detail of the actual area to be logged so that site damage can be avoided and integrated management objectives can be implemented. Specific goals of the operational level are:

(a) to identify acceptable logging systems, techniques and operating constraints;
(b) to specify the silvicultural treatments that will be required after logging;
(c) to determine cut block boundaries in such a way that a logging system can be used efficiently;
(d) to spell out special provisions for difficult or sensitive areas;
(e) to specify minimum acceptable site conditions after logging;
(f) to specify a maximum amount of ground disturbance that will be acceptable; and,

---

[1]Sub-unit - generally, a geographic unit normally centered within watersheds.

(g) to indicate the location of critical landings such as where cable logging will be used on steep slopes and where the landings dictate the shape and size of cut blocks.

The plan at this level oversees the implementation of the programs developed at higher planning levels. Specified environmental constraints are incorporated into the operational plan. Actual site data collected will include identification of areas critical to fish and wildlife. One of the specific objectives of pre-logging assessment is to "determine the ecological characteristics [e.g. habitat type or forest ecosystem type] of the areas proposed for logging and, as a consequence the significant factors which will govern the establishment and growth of the replacement forest" (B. C. Ministry of Forests, Planning Division 1978). As well, this assessment will determine any other factor which is of significance to site preparation, reforestation, or other resource management objectives set for the area.

Present day assessment of the supply of timber and range resources leads to several conclusions about future management. The standing crop of old growth timber has been largely removed from the accessible, productive sites. The useable timber base has diminished for several reasons including increased concern for environmental protection and increased recognition of nontimber uses. Earlier cutting ages result in reduced timber yields. Rates of innovative advances in technology have not kept pace with the accelerating harvest of old growth stands. There is a greater than ever need for nontimber uses to be carefully integrated using the best information.

Within each Forest Region, alternative programs have been addressed in the five year program outlined in the Ministry of Forests Act (1978). Some thrusts of this program of special interest to wildlife include (B.C. Ministry of Forests, Information Services Branch 1980a):

1) rationalization of the productive forest land base through the creation of additional Provincial Forests;
2) improvement of silvicultural information or treatment opportunities, their kinds, location and amounts;
3) improving efficiency of fire control;
4) expansion of use of prescribed fire;
5) incorporation and management of additive Crown rangelands; and,
6) refinement of site specific silvicultural prescriptions based on ecosystem classification.

Part of this resource program will be the development of resource management plans for Crown forest and range lands, providing a systematic interdisciplinary approach to planning for multiple use (B.C. Ministry of Forests, Planning Division 1978).

3.4 Interagency Planning Processes for Land and Resources

3.4.1 Introduction

Each of the agencies with jurisdiction over either resources or land are engaged in internal planning programs. Examples of major agency plans include Timber Supply Area plans and reports (e.g. B.C. Ministry of Forests 1980); Regional Wildlife Management Plans (e.g. B.C. Ministry of Environment, Fish and Wildlife Branch 1982b); and the Agricultural Land Reserves. Each of these has been described as treating a particular resource in a "conceptual vacuum without discussion of possible interactions or conflicts with other uses of the land" (Strang n.d.).

There are a number of planning processes occurring in British Columbia that make some attempt at interagency coordination in planning. Some will have impact on wildlife and wildlife habitat decisions and management. Much of the following is from Dick et al. (1977), who describe the major components of the present administrative structure governing land and resource planning.

3.4.2 Environment and Land Use Committee

The Environment and Land Use Committee (ELUC) is a formal provincial level committee of nine cabinet ministers: Environment; Forests; Lands, Parks and Housing; Agriculture and Food; Energy, Mines and Petroleum Resources; Transportation, Communications and Highways; Health; Municipal Affairs; and Economic Development. This committee has very broad powers of policy-formulation and decision-making in resource management and land use matters. This is the highest level of interagency administration; the committee makes recommendations directly to the Lieutenant Governor-in-Council. This is a necessary level of planning for major policy decisions, often used when conflicts of view are between resource users in diverse sectors of the public and within the ministries of government (B. C. Ministry of Forests, Information Services Branch 1980c).

3.4.3 Environment and Land Use Technical Committee

The next level in the provincial planning process is the Environment and Land Use Technical Committee (ELUTC), composed of the deputy ministers of the various ministries represented on the ELUC. It provides the highest level of public service resolution of problems - otherwise, problems are politically resolved at the ELUC level (Dick et al. 1977).

3.4.4 Regional Planning Processes

Within regions, multiagency planning has occurred in five main forms: folio plans, coordinated resource management plans (CRMP's), referrals, deferred area plans, and Regional District plans.

1) Folio plans are initiated by the Ministry of Forests Districts upon the request of a government agency that may have environmental concerns. These plans have a definite emphasis toward timber extraction. They have been generally carried out in undeveloped watersheds; valleys that have existing logging are not "folioed" unless major resource concerns are expressed. In recent years, few folios have been initiated. Though called a plan, folios are essentially coordinated inventory programs resulting in a set of inventory maps. The Forest Service then uses the folio as an aid to resource management decisions. Figure 8 illustrates the folio plan areas that have been initiated within the Kamloops Forest Region. Planning takes place on only a five year planning period and on single watersheds, and works within a regional regime of "outside" management decisions concerning annual allowable cuts, full commercial rotation time periods, and choices of silvicultural systems. These outside decisions cannot be addressed within the folio planning process.

Folios have also been used by the Ministry of Lands, Parks and Housing as a planning tool. These essentially consist of the same sort of process as do the forest folios, except the Crown land under consideration is not within provincial forests. Wildlife input, as with the forest folios, generally consists of an inventory map of major animal species distributions and a set of guidelines for general protection of habitat.

2) Coordinated Resource Management Plans were introduced to British Columbia in response for the need to resolve land-use conflicts on Crown rangeland, particularily where conflicts arose among cattle grazing, recreational uses, timber production and wildlife management (Strang n.d.). Planning is done by discussion among actual and potential users of the Crown land, with the purpose of arriving at a multiple use plan agreed to by consensus of the

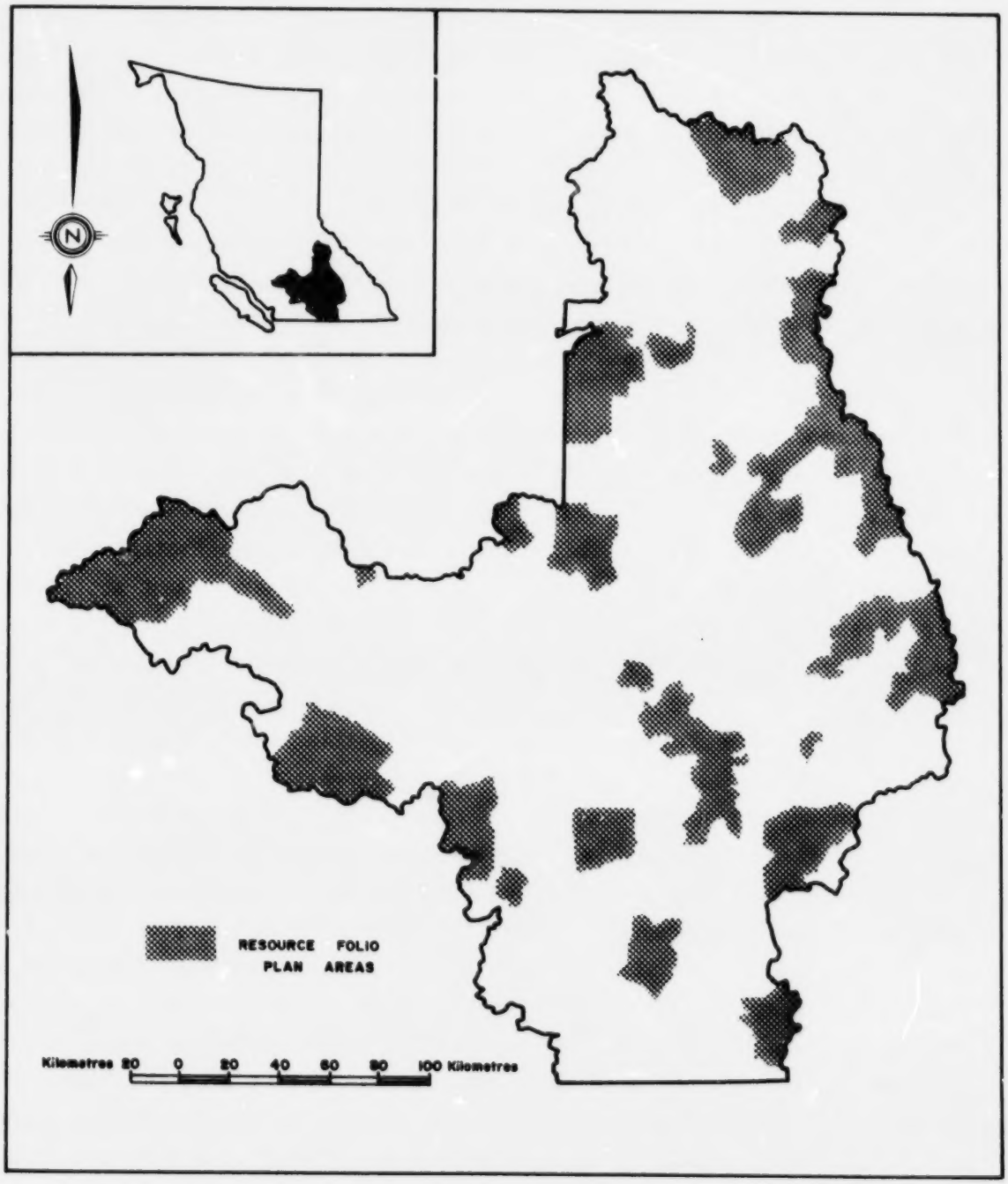


Figure 8. Folio plan areas in the Kamloops Forest Region (B.C. Ministry of Forests, Kamloops Region 1982b).

planning group. This plan can be considered an operational level plan that specifies conditions such as grazing intensities, rotation type, fence and trail construction and habitat manipulation. Funding assistance in planning and conducting the approved activities and treatments is provided through the Agriculture and Rural Development Subsidiary Agreement (ARDSA). This funding is due to be finished after early 1984. Figure 9 illustrates the areas covered by CRMP's in the Kamloops Forest Region. Data inventory is not a major thrust of the plan.

3) Referrals are line agency requests for inter-agency review, prior to decisions on resource allocation. These are directed to various concerned agencies for comment on specific resource concerns to that agency. Referrals have been described as only a "short-term, stop-gap measure to ensure that not too many resource management options are lost while proper planning processes are developing" (Dick et al. 1977). A varying basis for referrals exists - some are mandatory under legislation while others are part of a formal or informal system for better multiple resource decisions. Foubister (1979) described the Fish and Wildlife Branch involvement with various referral systems. Referrals presently occupy a major time commitment of the Habitat Protection biologists and their staff. Except for a few major development applications (e.g. transmission lines and pipelines; hydro developments; major coal development), and pesticide applications, most referrals are handled at the regional level. A lot of the water referrals deal specifically with water supplies and/or stream manipulation that have little direct impact on wildlife habitat. However, many of the 7000 - 8000 referrals per year received by the Fish and Wildlife Branch (Foubister 1979) from the Ministry of Forests and the Ministry of Lands, Parks and Housing have direct impact on terrestrial systems.

4) Deferred area planning (Crown land plans) is a relatively new planning process. There is at present a "conflict" between the Ministry of Lands, Parks and Housing and the Ministry of Forests over jurisdiction over Crown land not presently alienated or assigned to Provincial Forests. The planning program to resolve ultimate land use options in areas identified as problem areas is often referred to as deferred area planning. However, this program allows other agencies with an interest in the land base to have an input. If the primary use of the land is found to be multiple resource, that land will probably be given Provincial forest status (J. Weinard, pers. comm.). Conditions of management may be included, especially if primary values are other than timber or range. If the best primary use is found to be single use, it will be given

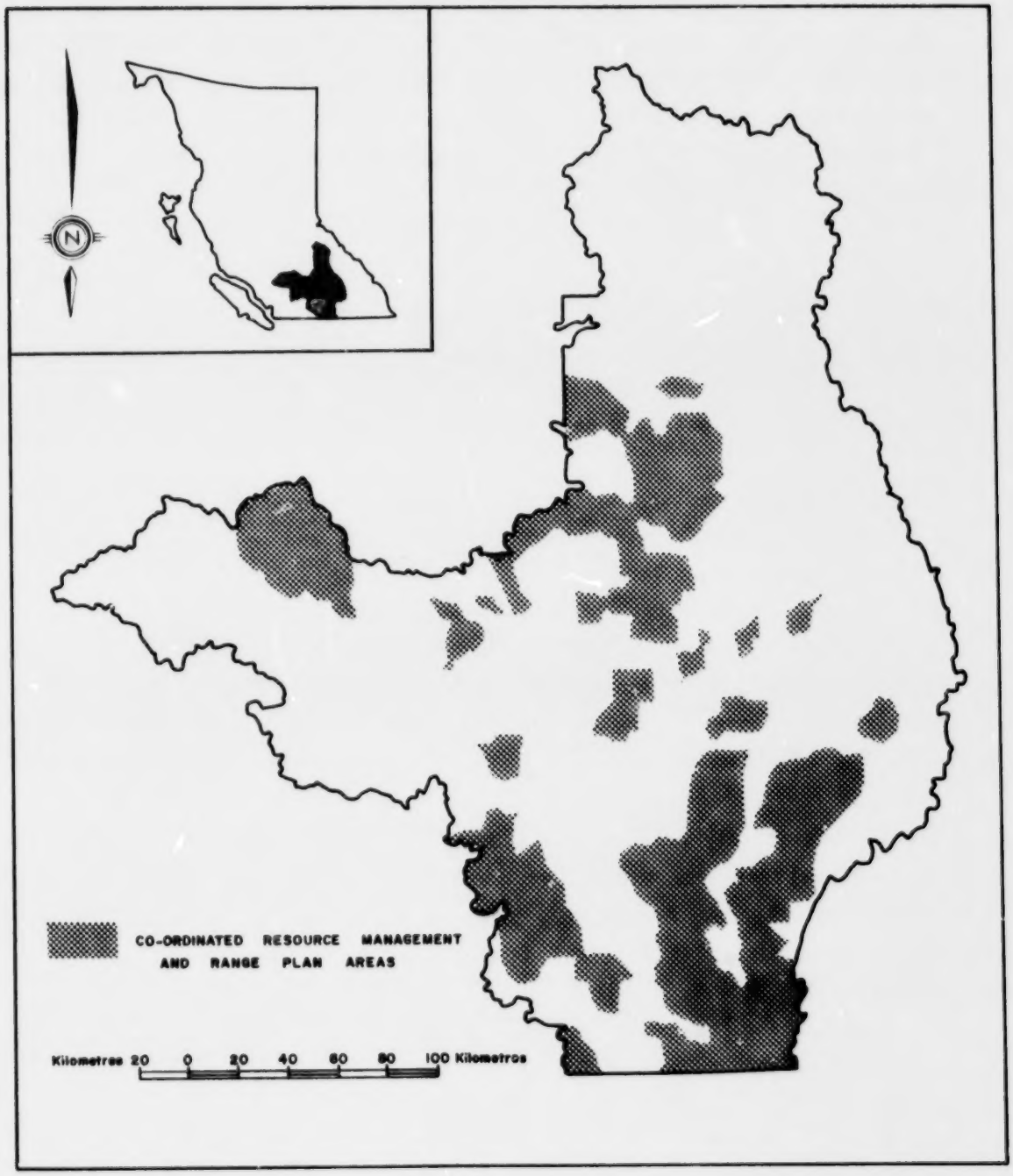


Figure 9. Coordinated resource management and range plans in the Kamloops Forest Region (B.C. Ministry of Forests, Kamloops Region 1982a).

the appropriate Crown land designation. Included is the possibility of forming Wildlife Management Areas, Ecological Reserves and possibly, provincial parks or recreation areas. Because much of this land base in conflict is valley bottom or lower valley slopes, many of the resources have their highest capability on these lands. A major underlying thrust of these plans was to better define the provincial forest/nonprovincial forest designations by more detailed studies. This has been substantially completed (C. Highsted, pers. comm.).

5) Regional District plans are undertaken in various portions of the regional districts. A Technical Planning Committee provides inputs into official settlement plans within these regional districts. The Fish and Wildlife Branch has representation on the committee and provides inventory information and recommendations for the settlement plans (P. Holman, pers. comm.). These plans can be considered to be a committee approach to the referral process.

3.4.5 Strengths and Weaknesses of the Planning Processes

Much has been written about the strengths and weaknesses of the current approach to planning land use in British Columbia (Strang n.d.; Dick et al. 1977; B. C. Ministry of Environment, Fish and Wildlife Branch 1982b; Foubister 1979). Most of these discussions have dealt more with the procedures or the process itself and not too much about the quality of the inputs. Some specific weaknesses in the various plan types are discussed below.

The established pathway of discussion of interagency plans from the resource regions through technical levels to the political level appeared to function relatively well (W. Kastelen, pers. comm.) However, the disbanding of the regional resource management committees in 1983 may damage the excellent communications about interagency projects, leaving the major link to decision-making more directly political (through an MLA rather than a public service committee)(op. cit.).

Conflicting opinions on the value of the folio plans for wildlife interests exists (S. MacDonald, pers. comm.; J. Weinard, pers. comm.). Dick et al. (1977) list three major disadvantages of the folio plans for the Fish and Wildlife Branch:

1) management options are limited to discussions of timber extraction rather than forest land use
2) much of the watershed remains unplanned because of the inherrent five year planning period

3) because of limited management options oriented solely to timber harvesting, fish and wildlife interests are usually limited to protection rather than habitat improvement.

Due both to a lack of inventory information and a high rate of demand, plans are of necessity somewhat rudimentary in nature (Dick et al. 1977). Partly because of this lack of data, the setting of objectives tends to be generalized and imprecise (Strang n.d.). There are periodic reviews of the plans, but these also "lack specificity and are hampered by lack of data and the absence of a time frame for implementation of a plan" (Strang n.d.). Plans are initiated at the request of any of the participants - the CRMP procedure priorizes the requests and assures that the plans follow approved procedures.

An obvious advantage to involved groups in the referral process is that there is continual awareness of what and where things are happening to wildlife habitat within a region. Foubister (1979) suggests that the referral system could be improved by:

(a) greater consideration and implementation of Fish and Wildlife Branch recommendations and support for objections,
(b) better quality information on the application forms,
(c) enforcement of their Acts by other agencies,
(d) increased feedback regarding Fish and Wildlife Branch recommendations.

From the viewpoint of wildlife habitat, five overall weaknesses of the total planning framework are evident. First, the Ministry of Environment has no legislative control over the land base; therefore, wildlife habitat, and thus wildlife, is primarily managed through policy, liaison, discussion, and professional association (B. C. Ministry of Environment, Fish and Wildlife Branch 1982b).

Second, there is a lack of basic land use planning coupled with a commitment to manage land according to its highest capability. There are no general provincial or regional guidelines for overall land planning. Strang (n.d.) stated that "no overall land use policy for the province has yet been articulated, nor is there a clearly defined and explicit philosophy of land use". A standard hierarchical system of planning units is also lacking (Dick et al. 1977).

Third, a better wildlife inventory is needed to resolve specific land use problems. The quality of species inventory varies from good to poor, depending upon the animal concerned or, in some cases, the management unit (B.C.

Ministry of Environment, Fish and Wildlife Branch 1982b). The data on species habitat requirements are often fragmented and incomplete, especially for nongame species. Strang (n.d.) also noted the paucity of data concerning the effect of management practices on wildlife habitat. Much of the current management must "rely on the application of limited scientific information and the wildlife manager's experience and professional judgement" (B.C. Ministry of Environment, Fish and Wildlife Branch 1979:13).

Fourth, many of the basic concepts considered in existing legislation and program goals are not clearly defined nor are the intents of those statements laid out as clear policy statements and/or planning regulations (see Sections 3.2.6. and 3.3.3.).

Finally, the planning process for wildlife is aimed primarily at featured species management. Little effort is presently being devoted to managing for diversity or species richness. Wildlife plan objectives are usually in the form of population goals rather than areas of quality habitat needed. No attempt has been made to select species for management that will provide some indication of the welfare of a larger group of species (e.g. management indicator species of the U. S. National Forest Management Act of 1976).

3.5 Sources of Wildlife Information

Information on the natural history and biology of vertebrate species in British Columbia is somewhat fragmented and scattered. The agency with the broadest data base is the Vertebrate Zoology Division of the British Columbia Provincial Museum. The Museum has published a variety of reports on specific animal groups, both at the broad, general interest level (handbooks such as The Mammals of British Columbia [Cowan and Guiguet 1965]) and at the more detailed scientific level (occasional papers such as Field Studies of the Falconiformes of British Columbia: vultures, hawks, falcons, eagles [Beebe 1974]). The Museum also publishes Syesis, a journal dealing primarily with natural and human history in the Pacific Northwest. The Museum is the primary repository for data on vertebrate distributions and taxonomic records, as well as for special data collections such as the B.C. Nest Records Scheme, the Photo-record File, and bibliographic references. Presently, the Museum is in the process of producing a series of four bibliographic references for mammals, birds (two volumes), and reptiles and amphibians (two bibliographies have been published to date). These bibliographies are the first products of the Atlas of British

Columbia Vertebrates project. These atlases will organize natural history and all distributional data for the 611 species of vertebrates occurring in British Columbia by collating information from a wide variety of sources (see Table 3), such as unpublished material and historical field diaries and notebooks (Campbell and Harestad 1981). These atlases could resemble the species narrative publications being produced by the United States WFHR program (e.g. Figure 11), if pertinent natural history data were related to a habitat classification compatible with the habitat handbook. Another anticipated benefit is a provincial data bank of vertebrate data, easily accessible and updated (Campbell and Harestad 1981).

Most other wildlife data, especially for the larger vertebrates or game species, is gathered within the Ministry of Environment. The existing systems for wildlife data are currently under review. Wildlife mortality has received the greatest attention -- data sources include hunter samples, game checks, guide returns, compulsory inspection, problem animal complaints, road and railroad mortality, and fur returns (Wildlife Data Committee 1982). Data are also obtained by field census techniques, usually using sample units to estimate population numbers and structure. These data collection techniques include night light counts, pellet group counts, track counts, aerial survey, and radio collaring. Much of the data on the biology of the species are not readily available in written form -- they are contained only in the minds of the professional biologists or inaccessible filing cabinets. Reports dealing with species biology are rarely produced; when they are, they are rarely published. Recent exceptions to this are the Preliminary Species Management Plans -- these range in level of detail on biology and habitat from detailed (e.g. deer) to general (e.g. nongame birds).

University theses have been the largest forum for research data made available in written form. Again, however, emphasis has been directed toward game species. Two research programs have recently started publishing more reports detailing information on species and habitats -- these programs are within the Fish and Wildlife Branch and the Research Branch of the Ministry of Forests. Other sources of wildlife information include the Surveys and Resource Mapping Branch[1], (ungulate capability, estuary mapping and classification); Ducks Unlimited (Canada) Ltd. (habitat enhancement, waterfowl species counts and brood data); and Canadian Wildlife Service (Pacific Region) (migratory birds).

---

[1]formerly the Terrestrial Studies Branch; this work is carried out within the Habitat Assessment and Census Unit (formerly Wildlife Unit)

Table 3. Main sources of natural history information for mammals, birds, amphibians, and reptiles in British Columbia. Estimated total number of records are indicated (Campbell and Harestad 1981)

SOURCE	ESTIMATED NO. OF RECORDS
LITERATURE[a]	
Amphibians and Reptiles	10,000
Birds	250,000
Mammals	75,000
MUSEUM COLLECTIONS[b]	
Canada	90,000
United States	25,000
Foreign	5,000
FIELD OBSERVATIONS	
Biologists/Naturalists	300,000
DIARIES AND NOTEBOOKS[c]	
Collectors/Biologists/Naturalists	75,000
NEST RECORDS SCHEME	
Cards (1956 through 1980)	90,000
GAME HARVESTS	
Large Mammals	5,000
BIRD-BANDING	
Select Species	10,000
SEA-BIRD COLONY FILE	
Nesting Records/Associated Fauna	5,000
PHOTO-RECORDS SCHEME	
Amphibians and Reptiles, Birds and Mammals	1,000
TOTAL	941,000

[a]Includes published and unpublished information from 7,500 references.

[b]CANADA (British Columbia Provincial Museum, Cowan Vertebrate Museum (UBC), National Museum of Canada, Provincial Museum of Alberta and Royal Ontario Museum); UNITED STATES (American Museum of Natural History, California Academy of Sciences, Museum of Comparative Zoology, Museum of Vertebrate Zoology, United States National Museum, and others); FOREIGN (British Museum of Natural History, Royal Australian Museum and others).

[c]Records from D. Beacham, A. Brooks, R. W. Campbell, G. C. Carl, I. McT. Cowan, E. W. Godfrey, J. E. V. Goodwill, C. J. Guiguet, G. Hardy, W. H. Hesse, M. W. Holdom, H. M. Laing, A. L. Meugens, J. A. Munro, C. Patch, T. Pearse, K. Racey, G. R. Ryder, P. A. Taverner, T. Thacker, and W. C. Weber.

4 HABITAT HANDBOOKS IN THE UNITED STATES

4.1 Background and Related Legislation

In the past, planning on U.S. Federal forest and range lands was an activity delegated to varying land management agencies (Rodiek and Thomas 1980). The general management philosophy was to utilize the primary resources with due regard to other resource values. Many conflicts arose, especially in the 1960's, because there was no consensus about what constituted "due regard" (U. S. Department of Agriculture, Forest Service 1979c). The most significant factor that contributed to the conflict was disagreement about which resource would have highest priority in the resource management hierarchy; most disagreements centered around timber utilization. The timber management plans were guided by the overriding principle that commercial forest land be managed for near optimum timber yield, with some estimated concessions being made for other resources. These "considerations of other resources" were subject to a range of interpretations at the Ranger District level (U. S. Department of Agriculture, Forest Service 1979c).

Increasing human population and an increase in nontimber resource values have resulted in changes in attitude, with the public and the resource managers being uncomfortable with the existing decision-making process. As a result of these changes in attitude, a number of legislative changes made in the last two decades have given legal recognition to wildlife and wildlife habitat as important natural resources. This federal legislation includes the National Environment Policy Act (NEPA) of 1969, which requires that the environmental impacts and consequences of planned actions involving federal government funds be examined and revealed (Thomas 1979a); the Forest and Rangeland Renewable Resources Planning Act of 1974; the National Forest Management Act (NFMA) of 1976, which requires detailed and holistic plans be prepared for the management of National Forest System lands; and the Multiple-Use Sustained Yield Act (1960), which authorizes and directs that National Forests be managed for outdoor recreation, range, timber, watershed, wildlife and fish purposes and to produce a sustained yield of products and services.

The Forest Service has also been directed to include the public in the land management planning processes (U. S. Department of Agriculture, Forest Service 1979c). Though the Forest Service does not have a direct statutory mandate to analyse effects on all wildlife species, there is a multiple use mandate for management of the National Forest System that does include wildlife

(Sheppard et al. 1982). NFMA regulations (U. S. Department of Agriculture, Forest Service 1982a) require: 1) that fish and wildlife habitat will be managed to maintain viable populations of all existing native vertebrates in the planning area (39 CFR 219.12); 2) an effort be made to "maintain and improve habitat of management indicator species" (36 CFR 219.12); and 3) an effort be made to "provide for and maintain diversity of plant and animal communities to meet overall multiple use objectives" (36 CFR 219.13). This latter statement indirectly implies mandate to analyze impacts on all wildlife species.

4.2 Wildlife and Fish Habitat Relationships Program

Habitat handbooks are presently being developed in the United States as part of a Wildlife and Fish Habitat Relationships (WFHR) program. This program is coordinated by the United States Department of Agriculture (USDA), Forest Service, nationally through the Forest and Rangelands Renewable Resources Planning Act (RPA) program and locally through the Forest Land and Resource Management Plans under the National Forest Management Act (NFMA) (Nelson and Salwasser 1982). Nationally, this project is the coordinated development of regional, state or area WFHR programs that will "integrate wildlife and fish population and habitat inventory with species-habitat relationships models, habitat evaluation procedures, and a research and monitoring program to develop, test, and refine species-habitat ecology knowledge and our procedures for evaluating habitat quality" (Nelson and Salwasser 1982:174). WFHR has been described as a comprehensive organization of information in a format useful for managing wildlife through the management of their habitats (Sheppard et al. 1982).

Specific objectives of the program are to (Nelson and Salwasser 1982:175):

1) provide managers with the capability to predict wildlife and fish responses to habitat conditions and changes at both the community and selected species levels;
2) make information on species-habitat relationships and analytical models available to managers in formats usable at all levels of resource decisions;

3) implement application procedures that result in more efficient use of field and office time in inventory, analysis, planning, and monitoring;
4) capitalize initially on existing local resource inventories, analytical models, research findings, and data management systems through better coordination within and outside the Forest Service;
5) facilitate the evolution of integrated, multi-resource classifications, inventories, and analytical models; and,
6) provide a mechanism for identifying information needs and guiding research and development efforts to fill knowledge and technology gaps.

The United States has 77 million ha of national forest land and water. Administratively, these lands are divided into nine regions and two areas. Each region has a WFHR program, with the goal of providing "a systematic method for evaluating habitats for all fish and wildlife species so that they can be effectively considered in land and resource planning" (Nelson and Salwasser 1982:175).

The WFHR program is attempting national standardization of some of the basic parts of the regional programs. This includes the wildlife and fish inventory systems (Nelson and Salwasser 1982) that include information on:

1) species and habitat distribution, abundance, and condition;
2) maps, and a data base management system to provide ready access to the data, and;
3) species-habitat relationship models, that will encompass:
   (a) species taxonomy
   (b) habitat classification that allows use of other resource classifications and inventories
   (c) species ecology and life history information
   (d) species distribution maps
   (e) species habitat relationships coefficients
   (f) special habitat quality criteria and management principles
   (g) systematic way of managing information to provide ready access by users.

At the same time, application procedures are very flexible, using several methods of modeling, simulation, evaluation, etc. All these habitat evaluation procedures will be integrated into the regional planning process. A fourth part of the WFHR program will incorporate such activities as research,

development, and monitoring to validate and refine the preceding steps. An important attribute of the program is a similar approach to habitat classification throughout the program. The system employs a three level hierarchy, designed to allow for habitat identification from other resource classification and inventories at the first two levels (Nelson and Salwasser 1982). The three levels are:

1) dominant attribute of site (e.g. dominant vegetation or aquatic system)
2) structural or physical modifiers of the dominant attribute (e.g. successional stage)
3) specific habitat elements present (e.g. snags, logs)

A key feature of the habitat classification is that the first two levels should be identifiable through remote sensing at scales less than 1:30 000. Identification of most specific habitat elements would require field work. Each regional habitat classification will fit within this structure; adherence to other resource classification standards and schemes at the regional and state level is encouraged (Nelson and Salwasser 1982).

Species are related to habitat at three levels (Table 4). These different levels of resolution meet different management needs. Level 1 relates individual species to habitat on a site for each life requisite for an instant in time; Level 2 relates groups to habitats within an area for all life requisite needs over seasonal to annual periods; and Level 3 relates populations within an area for potential habitat capacity over many years (Nelson and Salwasser 1982). Different levels relate to different levels of planning and analysis (Figure 10).

Some habitats are so important for a variety of wildlife or fish that they are addressed as special habitats (e.g. cliffs, talus slopes, snags). These special habitats will vary among regions.

4.3 Program Coordination

The first generation of research on wildlife-habitat relationships was carried out by a number of "isolated" groups (e.g. Thomas 1982; Patton 1978; Verner and Boss 1980b). Now the WFHR program is providing coordination of these various projects. Coordination at the national level is accomplished through a Steering Committee. The committee's function is to develop program objectives. Some standards may be developed for the regional programs. Each

Table 4. Utility of different levels of species-habitat relationships models in assessing wildlife or fish diversity and selected species habitat capabilities at project (= operational) and land use plan (= subunit) levels (Nelson and Salwasser 1982)

	Application			
Species-habitat relationships model resolution	Diversity analysis	Selected species population	Project	Land use plan
Level 1: Individual to habitat on site, related to life requisites.	Good for potential community richness: intended use (alpha level)	Poor: inadequate detail in level 1 models	Good: intended use	Good: intended use
Level 2: Groups to habitats in an area related to all life needs.	Poor if inadequate species coverage; Good if management indicator species represent all others. (beta and gamma levels)	Good: intended use	Good: intended use	Poor, most plan areas are too large and complex for level 2 models. Use level 3 model.
Level 3: Populations to habitats in an area, related to range capability expressed in numbers of animals.	Poor if inadequate species coverage; Good if management indicator species represent all others. (beta and gamma levels)	Good: intended use	Depend: most project areas are too small for whole populations: usually better to use level 2 models.	Good: intended use

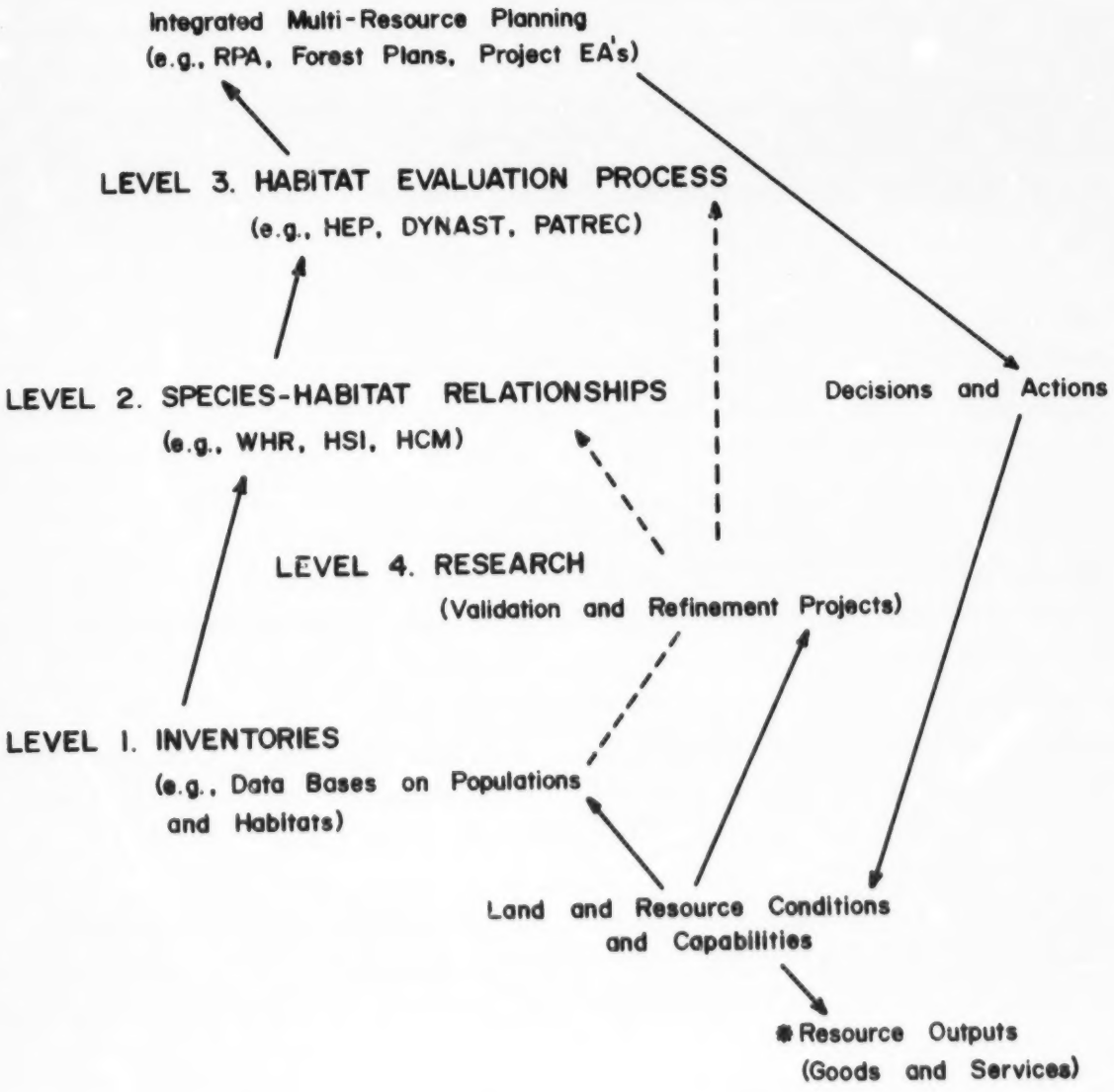

Integrated Multi-Resource Planning
(e.g., RPA, Forest Plans, Project EA's)
LEVEL 3. HABITAT EVALUATION PROCESS
(e.g., HEP, DYNAST, PATREC)
LEVEL 2. SPECIES-HABITAT RELATIONSHIPS
(e.g., WHR, HSI, HCM)
Decisions and Actions
LEVEL 4. RESEARCH
(Validation and Refinement Projects)
LEVEL 1. INVENTORIES
(e.g., Data Bases on Populations and Habitats)
Land and Resource Conditions and Capabilities
Resource Outputs
(Goods and Services)

Figure 10. Relationships between land resources, inventories, analytical models, habitat evaluation methods, research, and multi-resource decision processes (after Nelson and Salwasser 1982).

region has its own steering committee that includes line officers and representatives of cooperating agencies. The work of developing and implementing the regional program is done by informal technical task groups under the direction of a regional coordinator. A wide range of technical experts are involved as necessary.

4.4 Progress

All Forest Service Regions are well on the way to completing Level 1 models - while standards vary, all accomplish the same general goal: organization of pertinent knowledge in useable formats (Nelson and Salwasser 1982). Levels 2 and 3 are being developed by the regional steering committees. There is an increasing emphasis on the development, testing, and application of habitat capability models in forest management.

4.5 Strengths and Weaknesses

The major strength of the wildlife and fish habitat relationships program is the strong legislative, multiple-use mandate given the United States Forest Service for management within the National Forest System for uses including wildlife (e.g. NFMA regulations require that "fish and wildlife habitats will be managed to maintain viable populations of all existing native vertebrate species"). Another major strength of the WFHR program is the rapidly-developing national and regional coordination efforts - the programs are being standardized at their lower two levels, primarily involving the data base, but are being allowed to develop models and other analytical techniques in independent directions. Though this total process would now appear to be well organized, the program has only recently evolved from discrete regional projects to a nationally supported and organized program. The individual programs, though centralized and coordinated from designated National Forests, do involve input from a wide range of professional and technical personnel, including state biologists who have the responsibility of population management of animals. Some programs have compiled all the necessary information for the data bases within their own working groups (Thomas 1979c), while others have awarded contracts for compilation of that information (Marcot 1979a; Verner and Boss 1980a).

Another aspect of the program's strength is its effort to integrate multi-resource data acquisition and management systems with all groups interested in resource management. A habitat classification that can be directly related to

other resource classification, contributes to ease of integration, both within a program and among other programs. Because upper levels in this classification can be identifiable at large scales (1:30 000), information can be directly related in project application to the operational level of planning. Areas of pre- and post-treatment vegetation types and structural stages can be easily calculated to produce quantitative data on impact of alternative management practices on wildlife habitat and thus wildlife.

The WFHR program, as a national program, has two problems inherent in the system:

1) as the program is only being developed for National Forest land (approximately 12 percent of the United States), much of the country's land base and natural resources are not being considered; this is a land pattern problem;
2) there are problems coordinating habitat management, a federal responsibility, and population management, a state responsibility.

The WFHR program has three shortcomings or weaknesses:

1) the data base is in need of much further investigation for validation of these data (Sheppard et al. 1982). Mossman (Marcot 1979a), one of the contractees of species-habitat matrix data, feels that the data base is very weak and should always be used with a strong input of field investigation; data are not available in sufficient detail to objectively fill in the species-habitat matrices for every species; this is a shortcoming of all models;
2) there is lack of equal progress in all regions (H. Salwasser, pers. comm.);
3) there is a reluctance of researchers to see the need and value in building the system (H. Salwasser, pers. comm.).

4.6 Habitat Handbooks of the Western United States

Information on wildlife/habitat relationships in the form of a first generation, simple model may be found in two forms in the western United States - published in some manner of handbook (e.g. Thomas 1979c; Verner and Boss 1980a; Thomas and Maser 1979-1983; U. S. Department of Agriculture, Forest Service 1981k; Wischnofske 1977b) or available from a computer data base (U.S. Department of Agriculture, Forest Service 1981l; U.S. Department of Agriculture, Forest Service 1981m; Salwasser and Laudenslayer 1982). The

typical United States' habitat handbooks are now composed of six sections - species narratives, habitat classification, emphasis (feature or management indicator) species, special habitat components, species/habitat matrices, and management options. Each of these sections will be presented in greater detail in the following sections. The various individual handbooks may lack some of these sections - for example, Thomas (1979c) and Thomas and Maser (1979-1983) lack species narratives, whereas Laudenslayer (1982) and Verner and Boss (1980a) presently lack sections on special habitat components and featured species (these are presently being prepared for the entire Pacific Southwest Region).

4.6.1 Species Narratives

Species are presented within a standard taxonomy classification framework. Species narratives form the basic data set for the species-habitat models. Pertinent details about the natural history of each species are summarized for several information categories (see example in Figure 11). These categories usually include:

1) status - legal status and ecological status/abundance of the report area
2) optimal habitat or distribution/habitat - summary of successional stage and vegetation types in the species-habitat matrix which are used for breeding or feeding at the optimal use level
3) special habitat requirements - items deemed to be essential for a given species to occur regularly or to reproduce. Intended to clarify other information provided for the species; it is often an expansion of that category in the species/habitat matrix
4) breeding - gives information on breeding seasons; types of nesting, denning, or egg-laying sites; and numbers of eggs laid or offspring born. With reptiles and amphibians, breeding season refers to time of egg-laying. Nest site requirements of birds also includes nest height where available
5) territory/home range - contains information on ranges and averages of the area of both home ranges[1] and territories[2]

---

[1]home range - area covered by animal during foraging expedition.

[2]territory - part of home range defended against other species or other members of the same species.

Flammulated Owl

B064 (*Otus flammeolus*)

STATUS. No official listed status. Common summer resident in suitable habitat; among most migratory of all owls, with most migration thought to be nocturnal.

DISTRIBUTION/HABITAT. Breeds in conifer habitats from ponderosa pine type up to red fir forests. Prefers low to intermediate canopy coverage, particularly common in suitable ponderosa pine forests.

SPECIAL HABITAT REQUIREMENTS. Yellow pines or black oaks (Marcot, pers. commun.) in nesting habitat, nest cavities.

BREEDING. Breeds from late April to early October, with peak from mid-June to mid-July. Nests almost always in flicker nest cavity in aspen, oak, or pine. Nest sites range in height from 7 to 25 ft (2.1 to 7.6 m). Clutch size 2 to 5, with mean of 3.5.

TERRITORY/HOME RANGE. A crude map in a study of territories in Sierra Nevada ponderosa pine forests suggests territories ranging in size from about 7.4 to 15 acres (3 to 6 ha) (Marshall 1939). Data on home range lacking, though Winter (1974) found a density of 2.1 males per 100 acres (40 ha) in the Sierra Nevada.

FOOD HABITS. Feeds primarily on insects, but also some spiders. Takes prey from the air, foliage, or ground. Sometimes searches for and pounces on food, more often hawks for insects from a perch.

OTHER.

REFERENCES. Marshall 1939, Karalus and Eckert 1974, Winter 1974.

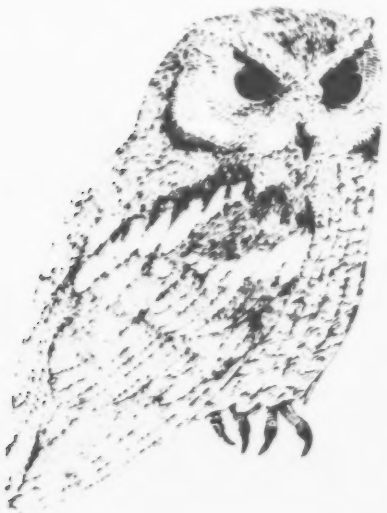


Figure 11. Example of species narrative (Verner et al. 1980:156).

6) food habits - includes main food items; main foraging substrates; main foraging techniques; dietary water requirements; (this category was not consistently used)
7) other - may include management practices that could be used for maintaining or improving habitat(s) of each species, or practices having extremely detrimental impact; this category is often left blank; also, a detection category has been used that summarizes methods of detecting reptiles and amphibians (Airola 1980a)
8) references - lists most informative references for a species; they are the most recent and contain references to the most useful articles on the species; they provide the manager with a way to obtain other information or greater detail
9) distribution or range maps - approximate distribution of each species is provided on a map; much information is inferred from information on habitat preferences; some separating of breeding and nonbreeding distributions may be made, especially for bird species; some separation on season of use (e.g. winter vs. summer range) may be made.

4.6.2 Habitat Classification[1]

The second section of the handbook consists of a habitat classification. This classification varies among the various handbooks, including the use of an existing classification, a modification of an existing classification, or a new classification. In the Sierra Nevada zone of California, the habitat units (habitat types) are based largely on those found in Forest Cover Types of North America (Eyre 1980), with some modifications to reflect what is known of animal species distribution and habitat selection (Verner and Boss 1980b). Thirteen habitat types are described in the north coast/Cascades zones of California, based on eighteen of Kuchler's vegetation types (1977) and five additional types (Marcot 1979a). These five additional types were considered "azonal"; that is, not tied to a particular climate or elevational range (e.g. alpine meadows; annual grassland). For the Northeast Interior zone of California, twenty vegetation types were recognized. These types were based on plant communities (series) classified by CALVEG (Parker and Matyas 1981) - each type contains one or more CALVEG plant communities (Laudenslayer 1982). Most recently, Salwasser and Laudenslayer (1982) have amalgamated the habitat classification from the aforementioned three California zones with that of Loe (in

[1]Habitat unit, habitat type, and plant community are three terms considered synonymous for this discussion--they are related to a vegetation-ecosystem class that is related to animal use.

progress) for the Southern California zone to form one single habitat classification with forty-four vegetation and aquatic types. Presently, Alaska uses a preliminary vegetation classification (Viereck and Dyrness 1980), being modified by Alaback for the habitat relationship program (Barton 1981; Alaback 1982). In Oregon, Thomas et al. (1979e) used a modified version of forest and range ecosystems developed by Garrison et al. (1977). This has resulted in fifteen plant communities. In the Great Basin rangeland handbook in Oregon, twenty-eight plant communities have been described (Dealy et al. 1981). In eastern Washington, fifteen plant communities have been described for the wildlife habitat project (Wischnofske 1978). In western Washington, fifteen plant communities have been tentatively described (Hall 1980). The Rocky Mountain Region has described twenty-five habitat types (U.S. Department of Agriculture Forest Service 1981k; U. S. Department of Agriculture, Forest Service 1981i). Most of these projects attempt to cross reference ("crosswalk") their classifications with that of Kuchler's potential natural vegetation of the conterminous United States (1964) or with Bailey's ecoregions of the United States (Bailey 1980; Bailey and Cushwa 1981), or with both systems. The 1979 National Assessment of wildlife and fish used a plant classification system designed by Garrison and others (Schweitzer et al. 1978).

Within a chosen classification of plant communities or terrestrial habitats, two further subdivisions have sometimes been applied: successional stage (also called structural stage or dominant vegetation size class) and canopy closure class (also called tree canopy cover class or ground cover class). Structure has been identified as an attribute of major importance to wildlife; and is invariably modified by management activities. These structural or successional stages also can be used as surrogates to a number of related environmental conditions such as forage and browse production, height of vegetation layers, and understory densities. U.S. habitat handbooks have been relatively consistent with the use of successional stages, especially with forested plant communities. Table 5 lists the successional stages of various habitat types for five habitat programs. California has also standardized several dominant vegetation size classes for shrubs when shrub canopy cover exceeds 10 percent (seedling shrub; young shrub; mature shrub; decadent shrub) and for herbs when herb cover exceeds 2 percent (short herb; tall herb). Criteria for these classes may include dominant vegetation class, diameter breast height (dbh), stems per acre, crown diameters, age, and crown closure.

Table 5. Successional stages of tree habitat types in some United States' habitat handbook projects

Blue Mountains[a] Rocky Mtn. Region[b]	Westside[c]	Sierra Nevada[d]	Alaska[e]	California[f]	Great Basin[g]
grass-forb	grass-forb (2-5 yrs.)	grass-forb	seedling-sapling and understory colonization (1-25 yrs.)	seedling tree	grass-forb
shrub-seedling (0-10yrs.)	shrub (3-10 yrs.)	shrub seedling-sapling	dense, closed forest and understory exclusion (20-150 yrs.)	sapling tree	low shrub
pole-sapling (11-39 yrs.)	open sapling-pole (8-20 yrs.)	pole-medium tree	mature, even-aged forest and understory reinitiation (150-250 yrs.)	pole tree	tall shrub
young (40-79 yrs.) mature (80-159 yrs.) old growth (160 + yrs.)	closed sapling, pole timber (40-200 yrs.) large sawtimber (10-100 yrs.) old growth (250 + yrs.)	large tree	old-growth stage (250 yrs. +)	small tree medium/large tree multi-layered tree	tree tree/shrub

[a]Reference Thomas et al. (1979a) - herbaceous habitats have only a grass-forb stage; shrub habitats have first two stages; some successional forest habitat types do not have mature or old growth stages

[b]Reference U. S. Department of Agriculutre, Forest Service (1981k, 1981l)

[c]Reference Hall (1980) - successional stages are referred to as stand conditions and assume clearcut regeneration treatments; modification of these descriptive categories are required for non-conifer-dominated communities; stand conditions are defined on the basis of a combination of heights, crown closure, and stem diameters

[d]Reference Verner and Boss (1980b) - chapparal habitat is divided into grass/forb, light shrub, and dense stand stages; there was no differentiation in other habitat types (see Figure 5.6.3); forested stages are defined on the basis of tree height

[e]Reference Alaback (1982) - described stages for western hemlock - Sitka spruce forests only

[f]Reference Salwasser and Laudenslayer (1982) - these classes are for conifer and hardwood stands, with greater than 10 percent tree canopy closure potential; classes based on crown diameter and dbh standards

[g]Reference Maser et al. (1982) - succession is more poorly understood and less predictable in rangeland communities than in forest communities; therefore, successional stages are called structural condition stages.

Some of the programs also introduce a canopy closure classification (Table 6). Later successional stages of forested habitats have been subdivided (U.S. Department of Agriculture, Forest Service 1981k; U.S. Department of Agriculture, Forest Service 1981i; Verner and Boss 1980b; Marcot 1979a; Salwasser and Laudenslayer 1982), as have some herbaceous, wetland, or desert vegetation types (Salwasser and Laudenslayer 1982).

4.6.3 Featured Species

A third section of the handbooks may deal with featured species (also called emphasis or indicator species). Featured species, a general term used by Thomas (1979a), are now more commonly called management indicator species (Mealey and Horn 1981; Salwasser and Unkel 1981; Thomas 1982). These species are highlighted in the planning process for setting habitat objectives. These are species identified by individual National Forests for planning and management attention and become the species for which resource goals, objectives, and standards are set (Salwasser and Unkel 1981). Objectives for featured species management require the production of desired species in appropriate locations and numbers.

Management indicator species are selected using set criteria from resource planning regulations and statutes. Salwasser and Unkel (1981) list four categories from which management indicator species are selected:

1) recovery species - identified for population increase because they are threatened or endangered;
2) featured species - the species are commonly hunted, trapped, or of high value for nonconsumptive recreational uses;
3) specific habitat indicators - species with potentially limiting habitat requirements (=low versatility scores [Thomas et al. 1979e]) that may be significantly affected by anticipating management activities, and/or;
4) ecological indicators - species that are members of associations that may be used as indicators to represent the effects of management on other species similarily adapted.

This latter class may be done using life forms (Thomas et al. 1979e; Wischnofske 1977b) or using guilds (Short 1982; Short and Burnham 1982; Severinghaus 1981). Table 7 lists some of the featured species chosen in different habitat handbook projects in the western United States.

Table 6. Canopy closure classes used in some United States habitat handbook projects

North Coast/ Cascades (California)[a]	Rocky Mountain Region[b] Western Sierra Nevada (California)[c]	California[d] tree/shrub	herbaceous
0 - 19%	0 - 39%	10 - 24% (sparse)	2 - 9%
20 - 69%	40 - 69%	25 - 39% (open)	10 - 39%
70 - 100%	70 - 100%	40 - 59% (moderate)	40 - 59%
		60 - 100% (dense)	60 - 100%

[a] Marcot (1979a).

[b] U. S. Department of Agriculture, Forest Service (1981m) - classes only used for successional stages with trees.

[c] Verner and Boss (1980b) - classes only used for successional stages with trees - same as that used in Region 2 (U. S. Department of Agriculture, Forest Service 1981k, 1982l).

[d] Salwasser and Laudenslayer (1982) - descriptions refer to both tree shrub and herbaceous canopy closure classes.

Table 7. Featured species in some United States' habitat handbook projects

Blue Mountains[a]	Great Basin[b]	Westside[c]	Alaska[d]	Eastern Washington[e]	
mule deer	native trout	salmonids	Sitka black-tailed deer	elk	chukar
elk	ferruginous hawk	deer		deer	great blue heron
	sage grouse	elk		ruffed grouse	marten
	pronghorn	spotted owls		barred owl	woodpeckers
	mule deer	bald eagles		trout	steelhead
	big horn			goshawk	mountain goat
				golden eagle	bears
				salmon	spruce grouse
				osprey	snowshoe hare
				blue grouse	mountain lion
				ducks	

[a]Thomas (1979c)

[b]Thomas and Maser (1979-1983)

[c]Brown (1980)

[d]Barton (1981), presently in process of selecting management indicator species

[e]Wischnofske (1978), management indicator species selected for each habitat type

4.6.4 Featured Habitats

A fourth section of the handbook may deal with featured habitats. These habitats are of such importance to a variety of wildlife or fish that it is appropriate to address them as special habitats and establish condition (quality) standards for the entire animal community dependent upon them (Nelson and Salwasser 1982). Thomas (1979c) divided these habitats into two categories - special habitats (or components) that can be created or altered by management activities and unique habitats that are created by geomorphic processes and generally cannot be artificially created. Examples of special habitats include riparian areas, snags, and edges; examples of unique habitats include cliffs, talus, and caves. Table 8 lists the featured habitats treated in some western United States handbooks. These featured habitats have been added to the classes of habitat described in Section 4.6.2 on the species/habitat matrices (see Section 4.6.5). In the California habitat handbooks, these featured habitats or components were treated under a heading called specific habitat elements (Salwasser and Laudenslayer 1982) or special habitat requirements (Verner and Boss 1980b; Marcot 1979e). This has allowed a wider range of attributes to be included in the models that are more specific in definition than those of Thomas (1979c). The elements are differentiated according to those consumed as diet items (vegetative diet elements, animal diet elements) and those used as a "substrate" for feeding (but not as a diet item), reproduction, and cover (live vegetation elements, dead or decadent vegetation elements, habitat edge elements, physical elements, aquatic elements, and man-made elements) (Salwasser and Laudenslayer 1982).

4.6.5 Species/Habitat Matrices

The fifth section of the handbooks consists of the actual species/habitat matrices. The relationships between vertebrate species and habitat classes and attributes are presented in tables or matrices. Several different formats have been followed, with varying attributes listed for each species-habitat class. Special habitats (e.g. snags, caves, marshes) may be handled by comments on special habitat requirements (see Figure 12) or by adding the special/unique habitats to the matrix (see Figure 14). In this latter example, Thomas (1979c) considered the approach to be an expansion and refinement of detail showing the orientation of the species to all habitats.

Rather than expressing only presence or absence of a species in a certain habitat unit, an attempt has been made to rate each habitat unit for a given

Table 8. Featured habitats (or components) in some United States' habitat handbook projects

Blue Mountains[a]	Great Basin[b]	Westside[d]	Alaska[e]	Eastern Washington[f]
rivers, creeks, streams	riparian zones	riparian zones	riparian zones	rivers
lakes, reservoirs, ponds	edges	bays, estuaries, and sandy beaches	snags and down material	streams
marshes, bogs, swamps	geomorphic and edaphic habitats[c]	edges	edges and diversity	sloughs
standing or slow-running water	man-made habitats	snags	cliffs, caves, talus	lakes
fast-running water		dead and down woody materials	avalanche chutes	reservoirs
edges		cliffs, talus, caves	rock outcrops	ponds
snags		wetlands	ice and snowfield	intermittent ponds, bogs
logs			barrier islands	marshes (five types)
burrows			sand dunes	cliffs
cliffs, rimrock			beach fringe	caves
talus				rims
caves				talus
				snags
				down material

[a]Thomas (1979c)

[b]Thomas and Maser (1979-1983)

[c]Includes cliffs, caves, talus, lava flows, sand dunes and playas (Maser et al. 1979b)

[d]Brown (1980)

[e]Barton (1981) - these special or unique habitats are not yet treated in very much detail

[f]Wischnofske (1978)

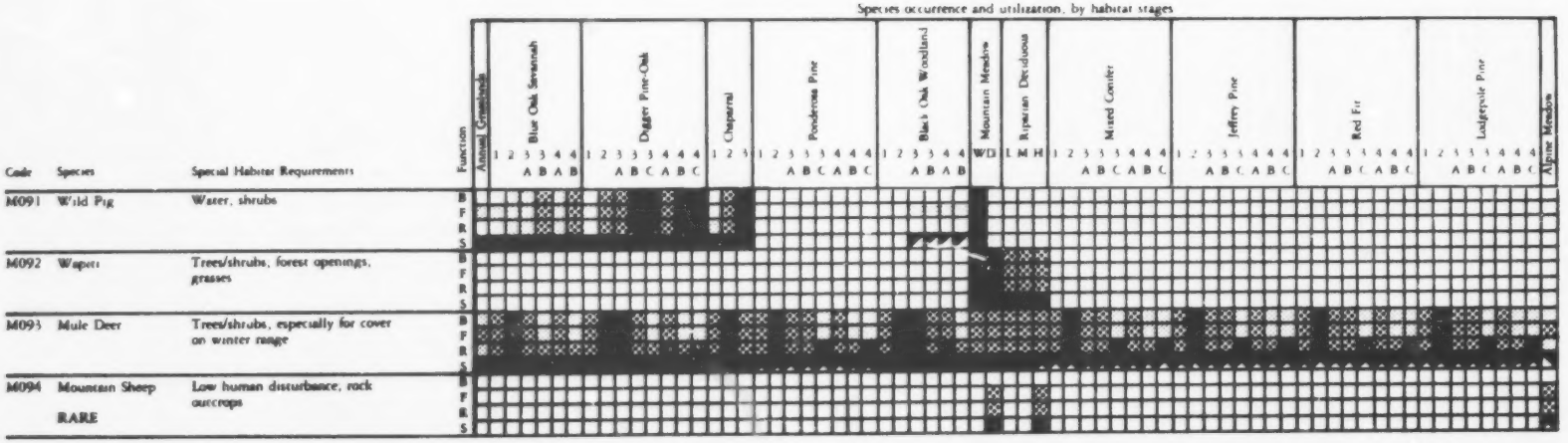


Figure 12 Matrix of species/habitat relationships from California (White et al. 1980:330). See Figure 13 for key to this matrix.

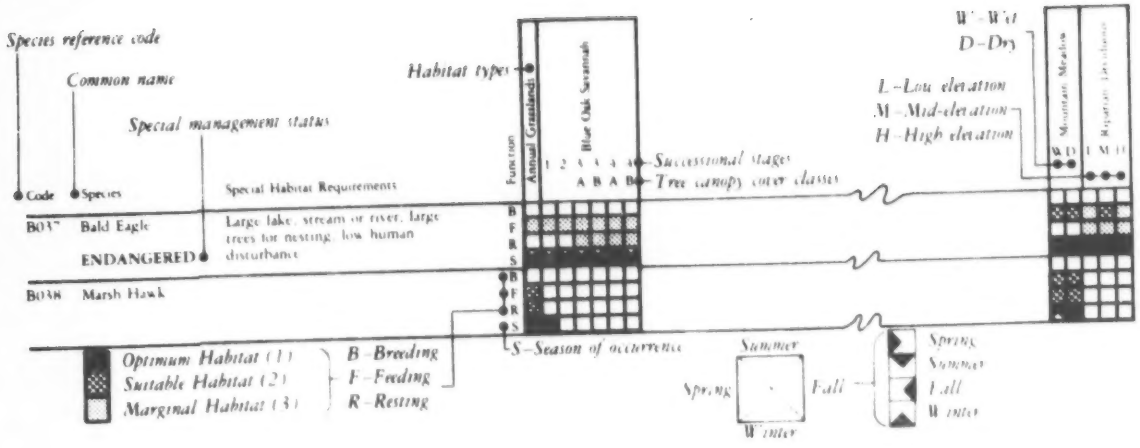


Figure 13. Key to matrix in Figure 12 (Verner and Boss 1980b:3).

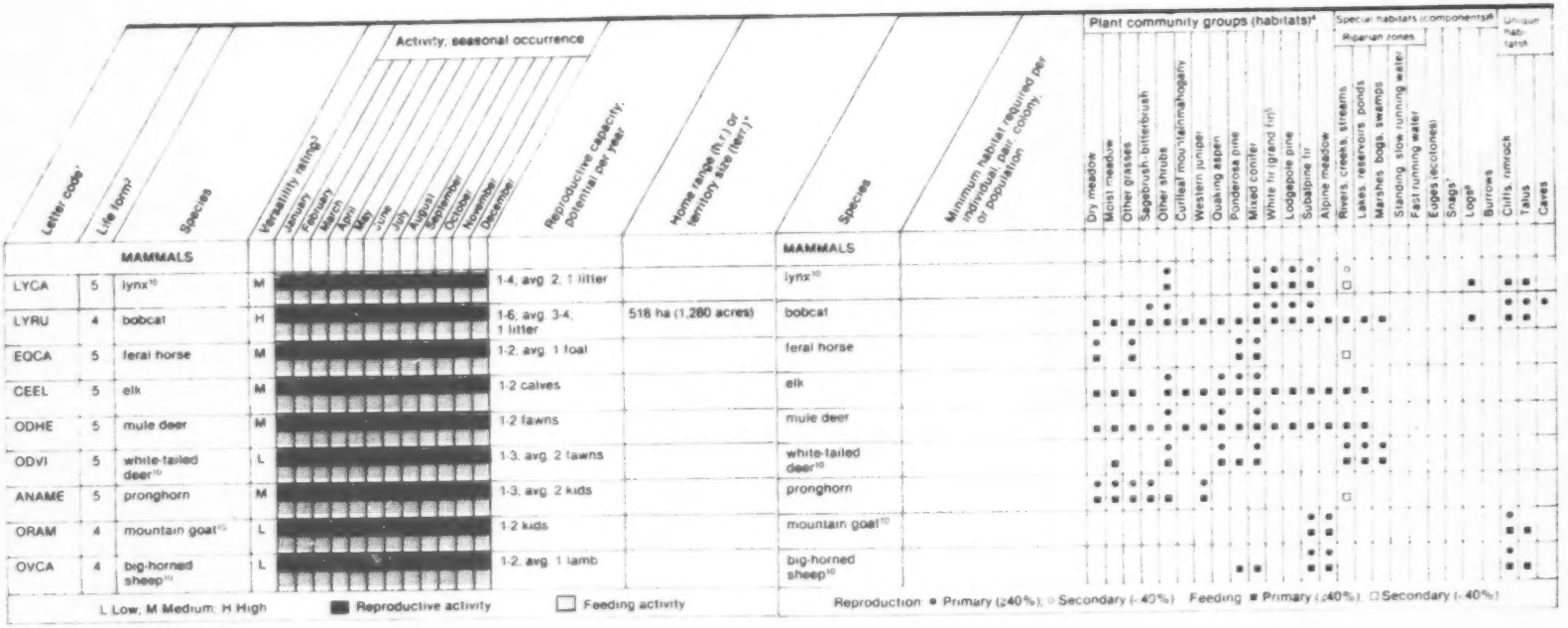


Figure 14. Matrix of species/habitat relationships from Oregon (from Appendix 6-composite occurrence and orientation list for 378 wildlife species [Thomas 1979c:244-245]).

species. At the same time, these rating coefficients have been separated by important life history categories. Several different rating scales for suitability have been applied. Thomas (1979c) uses three classes - primary (unit used greater than or equal to 40 percent of the time), secondary (used less than 40 percent of the time), and absent. Verner and Boss (1980a) use a four-class coefficient rating: optimum habitat is the best quality habitat for a species, as judged by high breeding density or frequency of use for feeding or nesting cover; suitable habitat is considered to be good habitat for the species, as judged by an intermediate breeding density or frequency of use for feeding or nesting; marginal habitat, as judged by observed animal density and/or frequency of use, may be used on a regular basis but does not contribute significantly over time to the maintenance of any population; and unsuitable habitat (not used). Salwasser and Laudenslayer (1982:20) used high, medium, low, and did-not-use ratings.

There is some variation in life history (biological function or life requisite) categories or activities. Some handbooks use only reproductive and feeding categories (Thomas 1979c; Wischnofske 1977b) while other publications used a more detailed system, such as breeding, feeding, and resting (U. S. Department of Agriculture, Forest Service 1981k; U. S. Department of Agriculture, Forest Service 1981l; Verner and Boss 1980a; Marcot 1979a; Laudenslayer 1982). Salwasser and Laudenslayer (1982) use the life history category cover rather than resting; cover is defined as all nonfeeding and nonreproductive activities including resting, thermal protection, escape, hiding and transit.

Season of occurrence has been separated by month (Thomas 1979c; Wischnofske 1977b) or by season (some combination of spring, summer, fall, winter) (White et al. 1980; Verner et al. 1980; Basey and Sinclear 1980; Marcot 1979e; Laudenslayer 1982; Salwasser and Laudenslayer 1982; U. S. Department of Agriculture, Forest Service 1981k; U. S. Department of Agriculture, Forest Service 1981l). A species is considered to occupy a geographical area if it is a yearlong resident or regular migrant, regardless of relative abundance (Salwasser and Laudenslayer 1982).

Species have been handled either phylogenetically within large groups (reptiles and amphibians; birds; mammals) as in Verner and Boss (1980a), or by life form (e.g. species group uses the same general strategy for feeding and reproduction, with an anticipated similar response to habitat manipulation) as in Thomas (1979c) or Wischnofske (1977b).

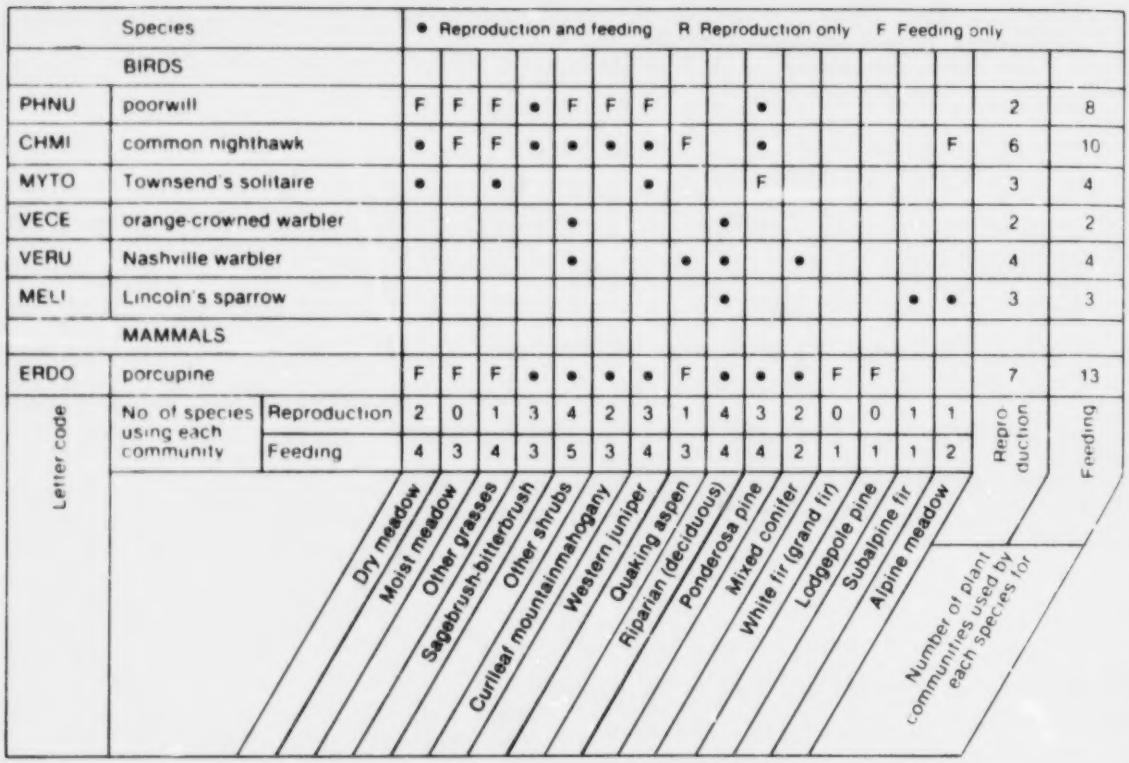
Two approaches to species/habitat matrix format have been taken: all information and coefficients are included on a large, single table (e.g. Figure 12 - 14) or the information is divided into a number of tables (e.g. Figure 15-17). Once the complete species/habitat relationships data are amalgamated, one has a wide range of options for data presentation, even if the data are not contained in a computer system.

4.7 Computerized Data Bases

There are two major uses of computer systems in the WFHR program in the United States. The first use is for storage of the large data sets for quick access and easy manipulation. The second use is for a wide variety of habitat evaluation processes that may include statistical models, optimization models, simulation models and economic models (e.g. Boyce 1978, 1980; U. S. Department of the Interior, Fish and Wildlife Service 1980b; Thomas 1982). Advantages of these computerized systems include (DuBrock et al. 1981):

1) more efficient data analyses of large data sets;
2) reduction in time and cost of data handling;
3) exploration of ecological analyses;
4) rapid testing of fish and wildlife models to predict effects of alternative management strategies.

This section deals specifically with various data storage and extraction programs presently being used in the WFHR programs, and is not intended as an overview of analytical models. The Forest Service has several operational species information systems. One is a national system required to provide input into periodic national assessments of all renewable resources on forest and range land (Schweitzer et al. 1978) The other systems are developed at regional levels for "systematically integrating biological information in forest management planning (DuBrock et al. 1981). These include the Forest Service Region 5 Western Sierra Nevada wildlife/habitat relationships program (Hurley and Asrow 1980), northeast interior zone wildlife/habitat relationships program (Laudenslayer et al. 1982), and north coast/Cascades zone wildlife/habitat relationships program (Marcot 1979a); Forest Service Region 1 wildlife/habitat relationships data base (Prather and Burbridge n.d.); Forest Service Region 3 RUN WILD (Patton 1978); and the Forest Service Region 6 wildlife/habitat relationships data base (WILDHAB) (Knight and Purcell 1980).

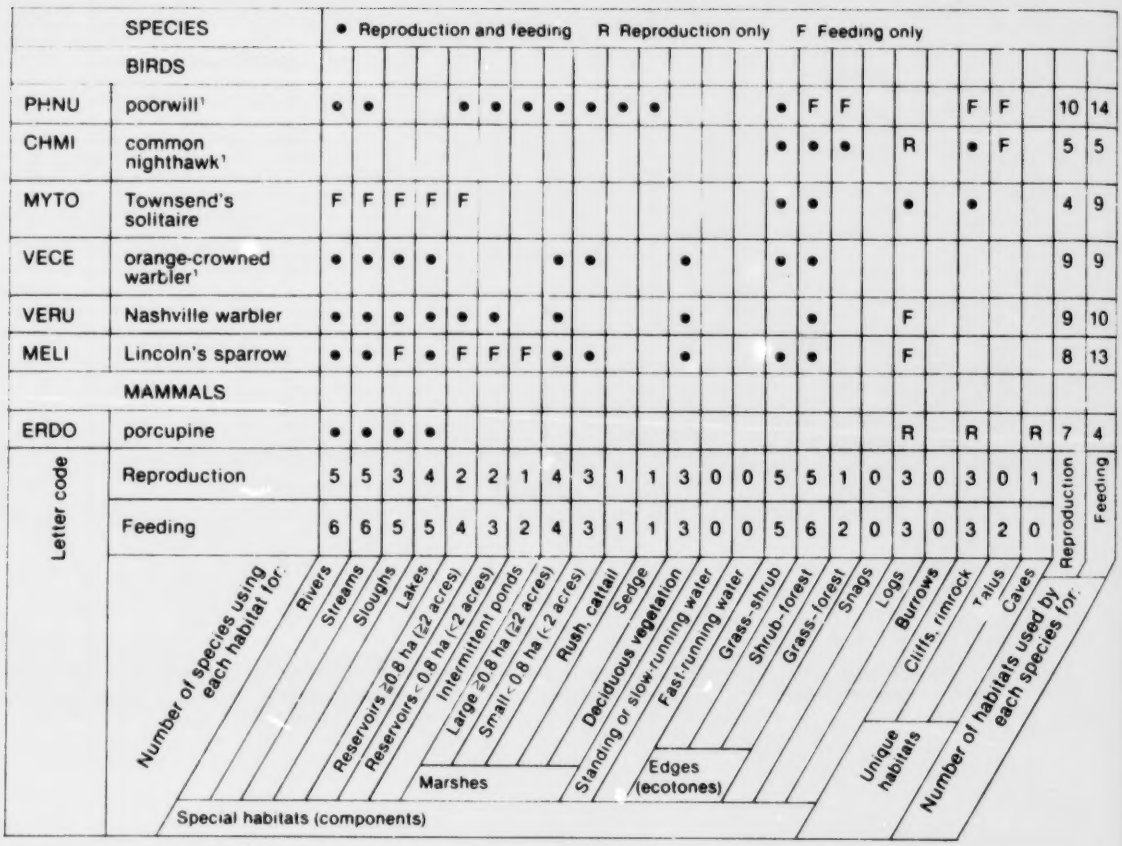


Letter code	Species		Dry meadow	Moist meadow	Other grasses	Sagebrush-bitterbrush	Other shrubs	Curlleaf mountainmahogany	Western juniper	Quaking aspen	Riparian (deciduous)	Ponderosa pine	Mixed conifer	White fir (grand fir)	Lodgepole pine	Subalpine fir	Alpine meadow	Number of plant communities used by each species for Reproduction	Number of plant communities used by each species for Feeding
	• Reproduction and feeding R Reproduction only F Feeding only																		
	BIRDS																		
PHNU	poorwill		F	F	F	•	F	F	F			•						2	8
CHMI	common nighthawk		•	F	F	•	•	•	•	F		•					F	6	10
MYTO	Townsend's solitaire		•		•				•			F						3	4
VECE	orange-crowned warbler						•				•							2	2
VERU	Nashville warbler						•			•	•		•					4	4
MELI	Lincoln's sparrow										•					•	•	3	3
	MAMMALS																		
ERDO	porcupine		F	F	F	•	•	•	•	F	•	•	•	F	F			7	13
	No. of species using each community	Reproduction	2	0	1	3	4	2	3	1	4	3	2	0	0	1	1		
		Feeding	4	3	4	3	5	3	4	3	4	4	2	1	1	1	2		

Figure 15. Matrix of species/plant community relationships (from life form 6, Appendix 8: wildlife orientation to plant communities [Thomas 1979c:255]).

Species			• Reproduction and feeding R Reproduction only F Feeding only							
BIRDS										
PHNU	poorwill		•	•	F	F	F	F	2	6
CHMI	common nighthawk		•	•	F	F	•	•	4	6
MYTO	Townsend's solitaire		•	•	•	•	•	•	6	6
VECE	orange-crowned warbler			•	F	F			1	3
VERU	Nashville warbler			•	F	F			1	3
MELI	Lincoln's sparrow		•	•	F	F	F		2	5
MAMMALS										
ERDO	porcupine		F	•	•	•	•		4	5
Letter code	No. of species using successional stage	Reproduction	4	7	2	2	3	2	Reproduction	Feeding
		Feeding	5	7	7	7	5	3		
			Grass-forb	Shrub-seedling (0-10 years)	Pole-sapling (11-39 years)	Young (40-79 years)	Mature (80-159 years)	Old growth (160+ years)	No. of successional stages used	

Figure 16. Matrix of species/successional stages relationships (from life form 6, Appendix 9 - wildlife orientation to successional stages [Thomas 1979c:277]).



	SPECIES	Rivers	Streams	Sloughs	Lakes	Reservoirs ≥0.8 ha (≥2 acres)	Reservoirs <0.8 ha (<2 acres)	Intermittent ponds	Large ≥0.8 ha (≥2 acres)	Small <0.8 ha (<2 acres)	Rush, cattail	Sedge	Deciduous vegetation	Standing or slow-running water	Fast-running water	Grass-shrub	Shrub-forest	Grass-forest	Snags	Logs	Burrows	Cliffs, rimrock	Talus	Caves	Number of habitats used by each species for: Reproduction	Feeding
	BIRDS																									
PHNU	poorwill[1]	•	•			•	•	•	•	•	•	•					•	F	F				F	F		10	14
CHMI	common nighthawk[1]																•	•	•		R		•	F		5	5
MYTO	Townsend's solitaire	F	F	F	F	F											•	•			•		•			4	9
VECE	orange-crowned warbler[1]	•	•	•	•				•	•			•				•	•								9	9
VERU	Nashville warbler	•	•	•	•	•	•		•				•					•			F					9	10
MELI	Lincoln's sparrow	•	•	F	•	F	F	F	•	•			•				•	•			F					8	13
	MAMMALS																										
ERDO	porcupine	•	•	•	•																R		R		R	7	4
Letter code	Reproduction	5	5	3	4	2	2	1	4	3	1	1	3	0	0	5	5	1	0	3	0	3	0	1			
	Feeding	6	6	5	5	4	3	2	4	3	1	1	3	0	0	5	6	2	0	3	0	3	2	0			

Special habitats (components): Marshes; Edges (ecotones); Unique habitats

Figure 17. Matrix of species/special and unique habitats relationships (from life form 6, Appendix 14 - wildlife orientation to special and unique habitats [Thomas 1979c:342]).

Benefits of quick data retrieval are obvious. Information can be used in procedures too tedious for manual perusal such as cross-tabulating several categories of information from the species/habitat matrix or information can be readily accessed by many personnel involved in a project (Marcot 1979a). At present, the California WHR program is in the process of standardizing the data among its four zones, by providing definitions and terminology standards for the wildlife/habitat relationship models (Salwasser and Laudenslayer 1982).

Several programs for data extraction from the computerized data bases are currently in use. Two of these retrieval programs are Qwick Query and System 2000. Qwick Query is used by the western Sierra Nevada program (Hurley and Asrow 1980). This program is essentially a skeleton program for retrieving information that can be adapted in different versions for specific types of information retrieval. Two permanent files storing the information from the western Sierra Nevada program are in the computer:

1) wildlife/habitat relationships data file; and
2) wildlife/habitat relationships dictionary file.

The data file contains all the attribute values[1,2] assigned to every wildlife species. The dictionary file contains all the attribute names[3] under which attribute values are stored in the data file. System 2000 ("S2K") is being used by the northeast interior zone in California (Laudenslayer et al. 1982) and by the Northern Region (Prather and Burbridge n.d.). This data file system is designed to be used with other resource data files in a land base data system. The field of data storage and retrieval in the United States WFHR programs is open to innovation (Marcot 1979a). The computer file format eases updating and editing of the species/habitat matrices, as well as allowing greater useability and innovation of use in the future. It also allows for easy input of data in higher level models and management programs such as DYNAST (Boyce 1978, 1980), FORPLAN (Kessell 1979) and habitat suitability indices models (Schamberger et al. 1982).

---

[1]attribute - category of information (Hurley and Asrow 1980)

[2]attribute value - a "value" that a particular animal (plant) place/thing has been assigned for an attribute (Hurley and Asrow 1980)

[3]attribute name - a "word" recognized by the computer as representing an attribute (Hurley and Asrow 1980)

5 WILDLIFE PLANNING: PRINCIPLES, PRESENT SITUATION, AND PROJECTED NEEDS

5.1 Role and Principles of Wildlife Planning

The general purpose of a wildlife plan is to analyze problems and appraise opportunities as identified by public issues and concerns. A plan also provides a "blueprint" for future actions, based on assessments of demand, supply, feasibility, and problems, and is directed toward specific objectives; plans also provide a basis for evaluation of progress. In a multiple use plan, there is a basic requirement for integration.

Each resource sector has specific management goals and requirements. Each goal, maximized to the extreme, could potentially result in the exclusion of other goals (Mealey and Horn 1981), so that goals must be integrated to achieve overall objectives. Integration does not necessarily mean that each resource sector's objectives will be fully realized. In most cases, integration requires compromises of objectives. Certain goals might be emphasized, as long as some "thresholds or standards for some minimum, biologically required, or socially demanded condition for each" were stated (Mealey and Horn 1981). The planning requires minimum management standards for each sector, based on stated management goals, concerns, and/or legislation.

Planning should be an essential step in wildlife management in British Columbia. This planning necessarily must be integrated, given the legislative mandate split between control of wildlife and control of habitat (see Section 3.2). From a wildlife perspective, management needs standards for minimally acceptable habitat conditions, in conjunction with objectives for the most desirable habitat conditions.

A set of principles for the integration of wildlife habitat resources with timber, range, and recreation (and possibly water and wilderness) resources must be based upon knowledge, experience, and the best scientific information available. From the viewpoint of the wildlife resource, these principles of integration[1] should:

1) resource goals

a) maintain and provide the diversity of plant and animal communities to meet overall multiple use objectives;

---

[1]Some of this information is extracted from unpublished information in the personal files of Dr. H. Salwasser, National Forest Ecologist, USDA Forest Service, 3825 E. Mulberry St., Ft. Collins, USA. 80524.

b) manage wildlife habitats to maintain viable populations of all existing native vertebrate species

c) improve or maintain the habitat of featured species

2) analysis goals

a) improve the status of threatened and endangered species so they no longer need the protection of the Wildlife Act;

b) utilize a hierarchical land ecosystem classification regime, standardized within the province and basic to all resources, for integrated analysis. It is doubtful at this time that each resource will use the same system; however, they should be capable of upward aggregation to a provincial system;

c) relate wildlife species to habitats/ecosystems in order to predict reponses to changes in vegetation structure and successional stages;

3) planning process goals

a) assemble existing wildlife habitat information into a useful format. Additional information, as needed, will be identified for response to public issues, management concerns, and to describe opportunities;

b) use professional wildlife biologists in the planning process to provide the technical information and represent the resource in the interdisciplinary team interaction[1];

c) consider wildlife and fish economic, ecological, and social values.

In the development of the planning process, a number of ground rules must be in place; these may be called planning criteria, outlining how planning is to proceed. The United States Forest Service divides planning criteria into two fields - decision and process criteria. Decision criteria are defined as "those used to identify the selection of a preferred alternative," whereas process criteria "includes rules and standards for all planning actions" (U. S. Department of Agriculture, Forest Service 1979b). Planning criteria are standards established prior to the planning activity "to guide judgements or decisions related to inventories, formulation of alternatives, analysis of the effects of implementation, evaluation of alternatives, ... and documentation". These criteria are based on the set of rules for the planning system (e.g. legislation, policies, regulations), goals and objectives of the resource programs, and economic and recreational needs of society. The criteria are

---

[1]This is the stand taken in the U.S. National Forests - wildlife biologists will closely work with other resource professionals but retain the role of providing the final wildlife input into the planning process.

based on the various plans developed by the individual resource agencies. There are a number of process steps taken that should address the three major wildlife topic issues: featured species, species richness or diversity, and habitat elements utilized by the animals. Other concerns may relate to items such as seasonal use and silvicultural and range management options (e.g. site preparation, seeding, thinning) (H. Salwasser, pers. comm.). The role of the planning unit must be put in context of higher level plans and objectives. Then, there must be provision of guidelines and standards for wildlife habitat that address the issues and concerns. This might entail setting specific objectives for habitat manipulation, ranked to meet the overall objectives. Prescription guidelines for each planning unit are then prepared in coordination with other resource specialists. It is important to provide for on-site flexibility. One then attempts to predict the consequences of those prescription guidelines by projecting habitat capability over time for each of the issues.

Decisions in management should be dependent upon an adequate data-base. This base should include:

1) inventory data and species and habitat information,
2) predictions of consequences of various management activities,
3) lists of vertebrates present,
4) standardized terrestrial habitat classes (related to ecosystems),
5) information on the relationships of each species to attributes of the habitat, and
6) information on current status of the species.

Where gaps in these bases exist, they should be identified in the plan and ranked by significance.

There are three main levels of planning in British Columbia: provincial, regional, and subregional (management area such as TSA's, MU, CRMP, folio, etc.)[1], but the same issues and concerns need not apply equally to all three levels.

5.2 Present Processes and Needs

The present trend in British Columbia, directed by legislation and policy, is for wildlife biologists to be able to relate all vertebrate species to

---

[1]See section 3.4.

habitat conditions and to predict the response of those species to habitat alterations. Though the legal mandate is not as strong in British Columbia as in the federal lands in the United States, continued pressure of conflicting uses on Crown land will increase the demand for wildlife professionals to improve integration of inputs into multiple use planning. At present, much of the wildlife information needed to meet this demand is scattered throughout the literature, is often insufficient, and in many cases is not reported in published form. Thus the existing knowledge and theory needs to be organized into a framework that can be utilized in land use planning. That process "requires innovative use of basic ecological principles in formulating systems for analyzing and interpreting existing data" (Thomas 1982:36).

The wildlife management goals for British Columbia indicate a need for an increased attention to species richness management, along with the traditional featured species management. However, it is not practical to study each animal in its habitat independent of the other species because of the large number of species requiring investigation. Thomas (1982) suggests that "there are probable advantages, in terms of cost and time, to be gained by describing habitats by categories such as plant communities and successional stages or structural conditions and, then, by relating the species present to those habitats". If this suggestion is followed, managers require a habitat classification and related information on the use of each habitat class by each vertebrate species. A means of assessing change within each habitat class caused by management activities is also required.

In the United States this need for better wildlife input into the planning process is being met by the development of a wildlife habitat relationships program, described in Chapter 4. This approach has been highly successful (H. Salwasser, pers. comm.; J. W. Thomas, pers. comm.).

5.3 Proposed Solution To Meeting Needs

The U.S. solution has apparent merit as a solution for British Columbia to better integrate wildlife with other resource programs. One of the primary aims of the U.S. program is to provide information for the development of forest plans: this aim is also true for British Columbia. The need for better integration of wildlife goals in our provincial forest and range planning process has been identified as a high priority for British Columbia. This priority requires two major items:

1) organized information and;

2) a system for applying information to local and regional needs.

With this in mind, the basic program goal for the wildlife habitat handbook project is:

to provide the manager with the capability to make better analyses and decisions in meeting goals and objectives for wildlife diversity and selected species through the application of species-habitat relationships to coordinated and integrated forest and rangeland planning and management.

Given the success of the American habitat handbooks, it is common sense to try a similar approach, modified to British Columbia conditons (Figure 18). We can capitalize on American experience, and this improved efficiency should allow more rapid product development. It is therefore proposed that the B.C. program goal be met by two major actions:

1) production of handbooks, data bases, and procedures dealing with species-habitat relationships for regional and district foresters, agrologists, and biologists, and;
2) implementation of the use of the handbook, data bases, and procedures.

The selection of criteria, discussion of options, and recommended choices for the first direction are given in Chapter 6; an outline for the proposed handbook, including some implementation needs, is described in Chapter 7.

5.4 Justification

At present, Ministry of Environment wildlife habitat managers have input into internal plans, such as regional wildlife management plans and strategic plans, and into multi-ministry plans, such as coordinated resource management plans, folios, and referrals (see Chapter 3). This input is provided by wildlife biologists and habitat protection biologists often with aid from wildlife research and habitat assessment support groups. Because of the problems of too few staff and heavy work loads, wildlife management goals are not being fully realized, especially in multi-agency plans. There is a strong need for a more detailed approach to integration and coordination, based on the principles described in section 5.1, and utilizing the wildlife habitat handbook as a management tool.

The wildlife habitat handbook is also perceived as a communications device. It provides, in written form, the concerns of wildlife managers, wildlife information needs, and approaches to habitat management that should be of tremendous use to other multiple resource managers in gaining a better

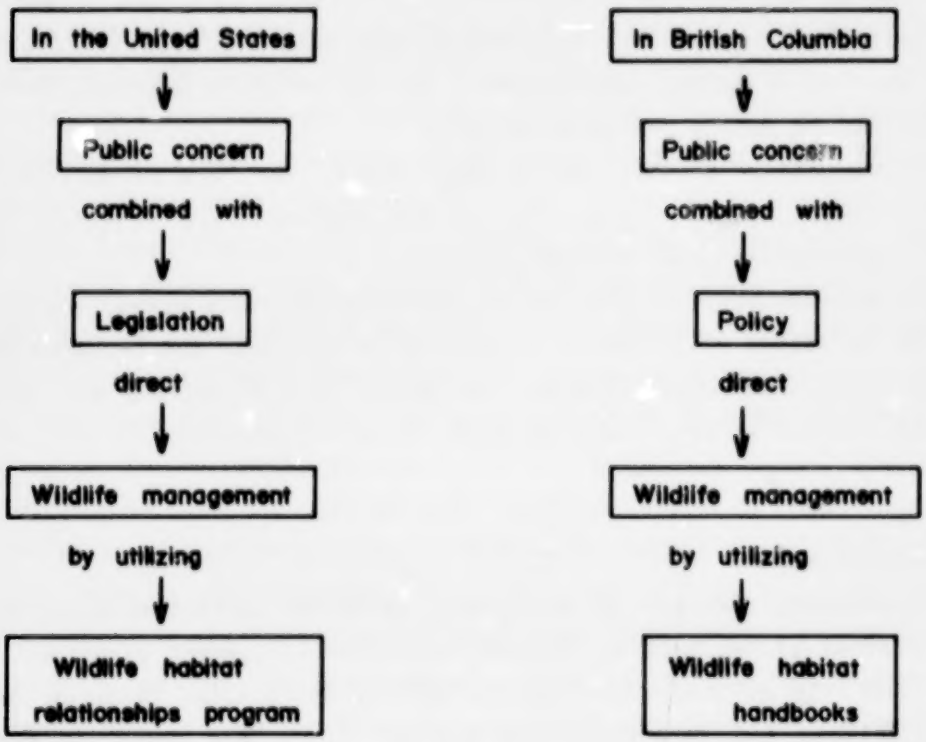


Figure 18. A proposed parallel relationship to wildlife management in the United States and British Columbia.

understanding of wildlife habitat relationships and responses to habitat management. At the same time, it provides the wildlife biologist with a written appreciation of options of other resource managers and a better understanding of impacts of wildlife plans on the other resource plans, especially those dealing with timber extraction. It is hoped that a carefully chosen habitat classification will form the common basis for planning.

Though it has been stated before, the wildlife habitat handbook is essentially an organization of information thought to be of prime importance for considering wildlife habitat needs in conjunction with other management activities. Its success or failure depends upon how the tool is utilized. Featured species management is perceived to be an area of wildlife management currently receiving much time and effort; goals for this aspect of management form are at least partially being fullfilled. Diversity or species richness management has been identified as an area that sadly lacks attention. Wildlife biologists must be willing to improve this area of management if the handbook approach is to be fully utilized.

5.5 The Future: Changing Directions and Needs

It is extremely difficult to anticipate how improved achievement of wildlife management goals might change future mandated requirements of resource agencies. However, improvements in the attitudes and philosophies of incorporating wildlife and wildlife habitat requirements must occur concurrently with the use of the wildlife handbook approach. In practical terms, this means that wildlife need better consideration in land planning for multiple resource use. The Ministry of Forests is the major agency with the land base mandate. There are encouraging signs that the attitude towards considering wildlife needs is improving. The 1978 Ministry of Forests Act provides a strong legislative mandate for wildlife consideration in provincial forests. This has been slowly followed by some optimistic policy statements and opinions. A recent statement on integrated resource use (B.C. Ministry of Forests 1983) states that "timber production is today, and will continue to be, a highly important component which will create the major impact on the forest lands, but it must now take its place in the overall scheme of integrated resource management. This confirms that <u>all</u> resource values must be considered and evaluated with respect to their supply, and the ... benefits they can produce". This same statement identifies the need for identification and implementation of a range of

strategies relative to other resource values to achieve necessary integration. This integration should take place at the region and district management levels (Table 9). Representation in this planning process will vary according to level of planning. In a recent speech, the Deputy Minister of Forests[1] emphasized the firm commitment of the Ministry to a policy of integrated resource. The best reaction to competing demands on forest land is not to be a protectionist but to commit the Ministry to a strong multiple use mandate. It has been suggested[2] that improving the wildlife input into these integrated plans will result in a greater deferment of timber from harvesting; in reality, it is felt that less pressure for complete removal of land from provincial forest status will be the result. Apsey[1] also suggested that present confrontations among resource agencies was solely the result of the agency reprentatives acting as proxies for various aspects of public interest. He identified the strong need for forestry professionals to participate in the development of integrated resource use plans to include flexibility to adjust plans and policies to cope with changing conditions.

There are good indications that better consideration of wildlife habitat needs will be carried out in further planning efforts in provincial forests. Now should be the right time for wildlife managers and planners to strongly pursue wildlife management goals. It is hoped that the wildlife habitat handbook will help in this pursuit both by providing an organization of wildlife-habitat relationships and by helping to communicate each other's procedures and objectives.

---

[1]Notes from a speech by T.M. Apsey to the Assoc. of B.C. Professional Foresters Annual meeting in Kamloops, British Columbia, on February 17, 1983.

[2]This suggestion arose from a meeting with the Environment and Land Use Committee of the Interior Lumberman's Association.

Table 9. Ministry of Forests planning systems (B. C. Ministry of Forests 1983)

Management Level	Planning System	Planning Function
Headquarters	Government Priorities Ministry's Management System	Forest Policy Formulation
Region	Regional Priorities Forest Management Plans (TSAs/TFLs)	Strategic Integrated Resource Planning
District	Local Priorities Development Plans	Tactical Integrated Resource Planning

6 CRITERIA, OPTIONS, AND RECOMMENDATIONS FOR THE HABITAT HANDBOOK

6.1 Introduction

In considering the implementation of the wildlife habitat handbook approach to resolve some of the identified needs of wildlife management in British Columbia, there are two broad classes of concepts to be considered: 1) logistics and 2) content. Logistics to be considered include geographical area for handbook coverage, consideration of authorship, and presentation opportunities and formats. Content to be considered includes the actual components of the species-habitat model, such as habitat classification, specific habitat elements, life requisites, capability coefficients and season of use, and specific management sections for featured species and featured habitats. The logistics and content options and recommendations are presented in the following sections (summarized in Table 10 and Table 12 [page 112]).

6.2 Geographical Area For Handbook Coverage

6.2.1 Introduction

British Columbia is too diverse a province to be covered by a single habitat handbook, though the proposed handbooks may have some common sections. The following criteria are important in deciding how to divide British Columbia into logical handbook areas:

1) homogeneity of species requirements: a model of species-habitat relationships must be as homogeneous and constant as possible for an animal within a habitat class. That is, one should avoid including within a single model differences in responses of a species within a habitat class. Animal requirements should remain reasonably consistent within the particular model, though this is not rigidly possible but will be a goal of that model. For example, it makes consistent prediction of impacts very difficult if moose require deciduous winter range in one area and coniferous cover in another area covered by the single model. The advantage of this criterion is that exceptions to the model predictions are minimized. One problem with this criterion is that since different species have different life requisite needs in different areas, choosing a single system will have varying impact by species.

2) usefulness to resource managers: users generally have responsibility for planning and/or management within administratively-defined units. The

Table 10. Criteria, options, and recommendations for logistic considerations

Subject	Criteria	Options	Recommendation
Handbook areas (Section 6.2)	1) relevance to primary factors influencing animal-habitat relation 2) ease of achievement 3) usefulness to resource managers 4) homogeneity of species requirements	1) wildlife ecosystem regions 2) terrestrial biotic areas 3) biogeoclimatic zonation 4) biogeoclimatic forest regions 5) forest regions 6) ecoregions 7) administrative units 8) combination of above 9) new classification	modified wildlife ecosystem regions
Authorship: Preparation of Handbook Components (Section 6.3)	1) distribution of workload 2) author commitment 3) authorship ethics	1) internal staff as time allows 2) internal staff with time commitment 3) contract writing 4) combination of 2) and 3) 5) single author	internal staff with time commitment
Authorship: Coordination and Technical Editing (Section 6.4)	1) maintain restricted editorial control 2) predetermine role and ethics	1) single dictator 2) triumvirate dictatorship 3) committee democracy 4) no editing or coordinating	triumvirate dictatorship with valid peer review
Presentation Opportunities (Section 6.5)	1) ease of updating or modifying 2) ease of access to information by users 3) minimum delay in making information available	1) singe volume, high profile handbook 2) several chapters published independently 3) unpublished photocopy publication 4) computer output 5) combination of above	several chapters independently published with computer data-base alternative

area encompassed by a handbook should be in some way related to these units as much as possible to allow for more practical and easier use of the handbook.

3) ease of achievement: simplicity per se is not a criteria; however, there are obvious logistical advantages in limiting the number of different models to the fewest possible number, while still maintaining biological validity of the data. By using some sort of geographically defined system already in place, time is also saved because a new system is not created. This of course is possible only if a suitable system satisfying other criteria is already available. The fewer the number of different sources of wildlife-habitat information, the easier it is for the user to become familiar with and to use the data base.

4) relevance to primary factors influencing animal-habitat relationships: the handbook areas should consider zoological considerations, at least in broad concepts. Some of the major determinants that affect a wide range of vertebrates are snow regime (depth and duration), physiography (including barriers to movement like large waterbodies), broad vegetative physiognomy (structure), temperature and moisture regimes, and migratory pathways.

The above criteria are applied to those existing systems that cover the entire province in the following sections. Each system is briefly described, with a discussion of advantages and disadvantages.

6.2.2 Wildlife Ecosystem Regions

Wildlife ecosystem regions (originally called biotic regions) are described as ecological land classes that integrate existing floristic and other types of classifications in a way that meets the needs for wildlife management and planning (Demarchi and Pendergast 1983). This is a new system, and there is a project underway to develop this classification for British Columbia, being done by the Terrestrial Studies Section, Surveys and Resource Mapping Branch, Ministry of Environment. The goal is to describe ecological requirements of terrestrial vertebrates at a strategic or basin (watershed) level scale. Objectives for the wildlife ecosystem region project include (Demarchi and Pendergast 1983):

1) defining areas of similar biotic potential;

2) mapping these areas at a scale of 1:2 million;

3) describing the ecological requirements of terrestrial vertebrates appropriate to that level of detail, and;
4) providing strategic-level guidelines on opportunities and limitations for habitat management.

The areas with similar biotic potential are defined mostly on a combination of macroclimatic processes (Marsh 1982) interacting with physiography (Holland 1964), with some consideration of biogeoclimatic zones (Krajina 1965; Pojar 1983). Development of wildlife ecosystem regions is necessary because no existing classification seemed suitable for providing an overview strategy of current and potential ungulate population status (D. Demarchi, pers. comm.). A preliminary map of wildlife ecosystem regions has been produced that has 23 regions, with 59 subregions (Figure 19).

The major advantage of using wildlife ecosystem regions to delineate handbook areas is that the units were based on a combination of factors to which animals respond and which provide their basic habitat needs: landform (physiography), climate, and plant community patterns with a refinement based on present and historic animal distribution patterns (Demarchi and Pendergast 1983). A disadvantage is that these "animal distribution patterns" have been related to ungulates. The applicability to other animal groups has not been evaluated. A second disadvantage for the handbook criteria is the number of units: 23 major regions. This problem could be overcome by grouping regions into a hierarchy based on similarities among the wildlife ecosystem regions. Such a stratification would lead to broader units with increased diversity but still valid for relating vertebrate species to habitats.

6.2.3 Terrestrial Biotic Areas

Terrestrial biotic areas were delineated for British Columbia by Munro and Cowan (1947); these biotic areas were identified on the basis of three criteria:

1) presence of distinctive plant species;
2) presence of distinctive animal species, and;
3) absence of plant and animal species from other biotic areas.

Thirteen terrestrial biotic areas were designated and mapped (Figure 20). Munro and Cowan (op.cit.) had difficulty in defining geographical and topographical boundaries, and assumed that the boundaries they adopted were largely tentative.

Figure 19. Wildlife ecosystem regions of British Columbia (Demarchi 1982).

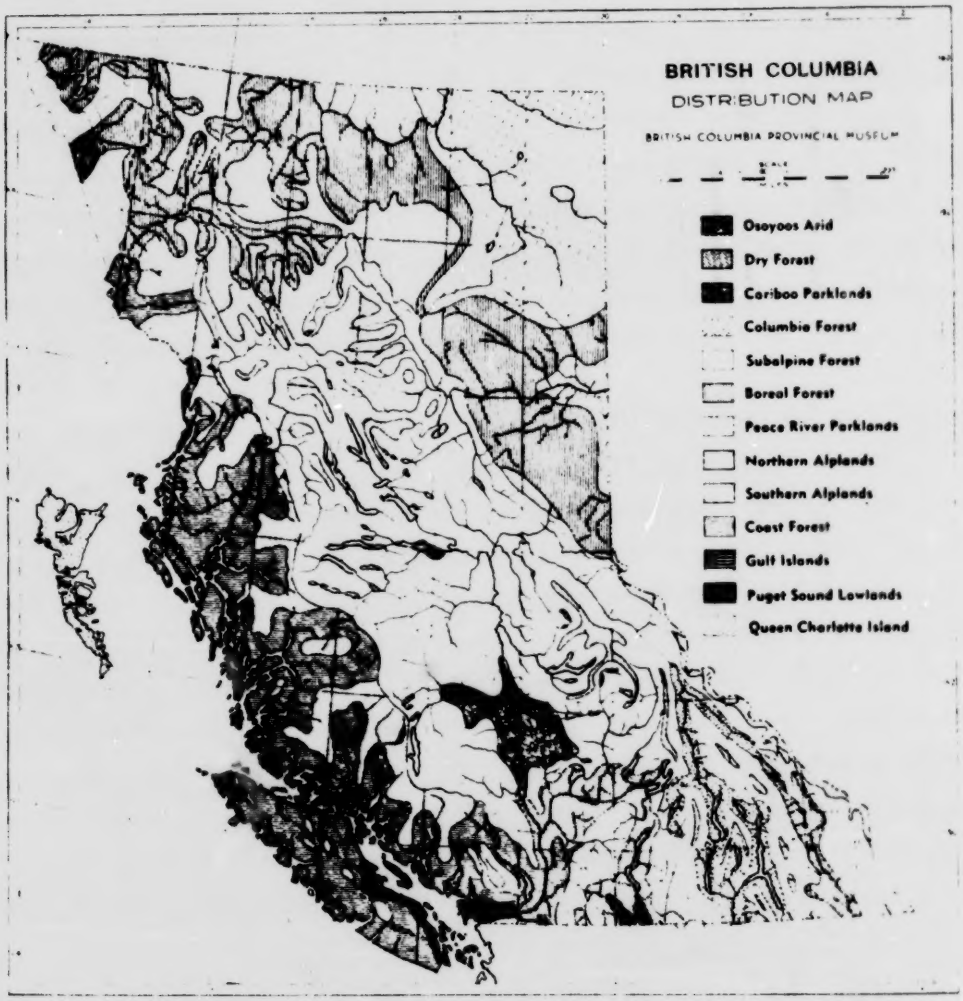


Figure 20. Terrestrial biotic areas of British Columbia (Munro and Cowan 1947).

The advantage of this biotic area classification is the emphasis on plant and animal distribution. Disadvantages have been summarized by Demarchi and Pendergast (1983). These include no systematic use of diagnostic criteria, very limited access and knowledge of the province at the time of the area designations, no major climatic input, and the production of some broad units with widespread latitudinal variation. The problem of access and limited data may not be a weakness restricted to this particular system. It is a problem with any classification. In light of a greater data base now available, the terrestrial biotic approach could be re-examined. No consideration of movement of animals between terrestrial biotic areas (e.g. seasonal migration) is included in the designation procedures.

6.2.4 Biogeoclimatic Zonation

The B. C. Ministry of Forests has been developing an ecosystem classification of forest and range lands since 1975. This classification is based, with some modifications, on the biogeoclimatic system developed by Krajina (Pojar 1983). Biogeoclimatic zonation deals with the distribution of ecosystems in relation to regional climate. Regional climate gradients associated with the distributional patterns of tree species has been employed as a classification basis for broad vegetation patterns, using soils as a third criterion for the differentiation and designation of biogeoclimatic zones (Brooke et al. 1970). Each zone is characterized in terms of a broadly homogeneous mesoclimate (primarily temperature and precipitation), ecosystems on the mesic (zonal) habitats, and zonal soil characteristics that reflect the dominant regional pedogenic processes of these habitats (Krajina 1965; Pojar 1983). Biogeoclimatic zonation maps are largely a reflection of plant distribution. Because climatic factors interact with mountainous terrain, this system leads to elevational bands of different zones.

An advantage of the biogeoclimatic system is the inclusion of a wide ecological scope of parameters, many of which are directly applicable to discussions of wildlife. This system is being widely utilized within the British Columbia Forest Service, and is being upgraded by regional research groups in the Forest Regions (Figure 21), including the production of zonation maps. From a handbook perspective, the disadvantage of the system is that larger animals and birds are distributed within a seasonal cycle in more than one biogeoclimatic zone due to latitudinal and altitudinal migration. A higher level in the biogeoclimatic hierarchy is the biogeoclimatic region or

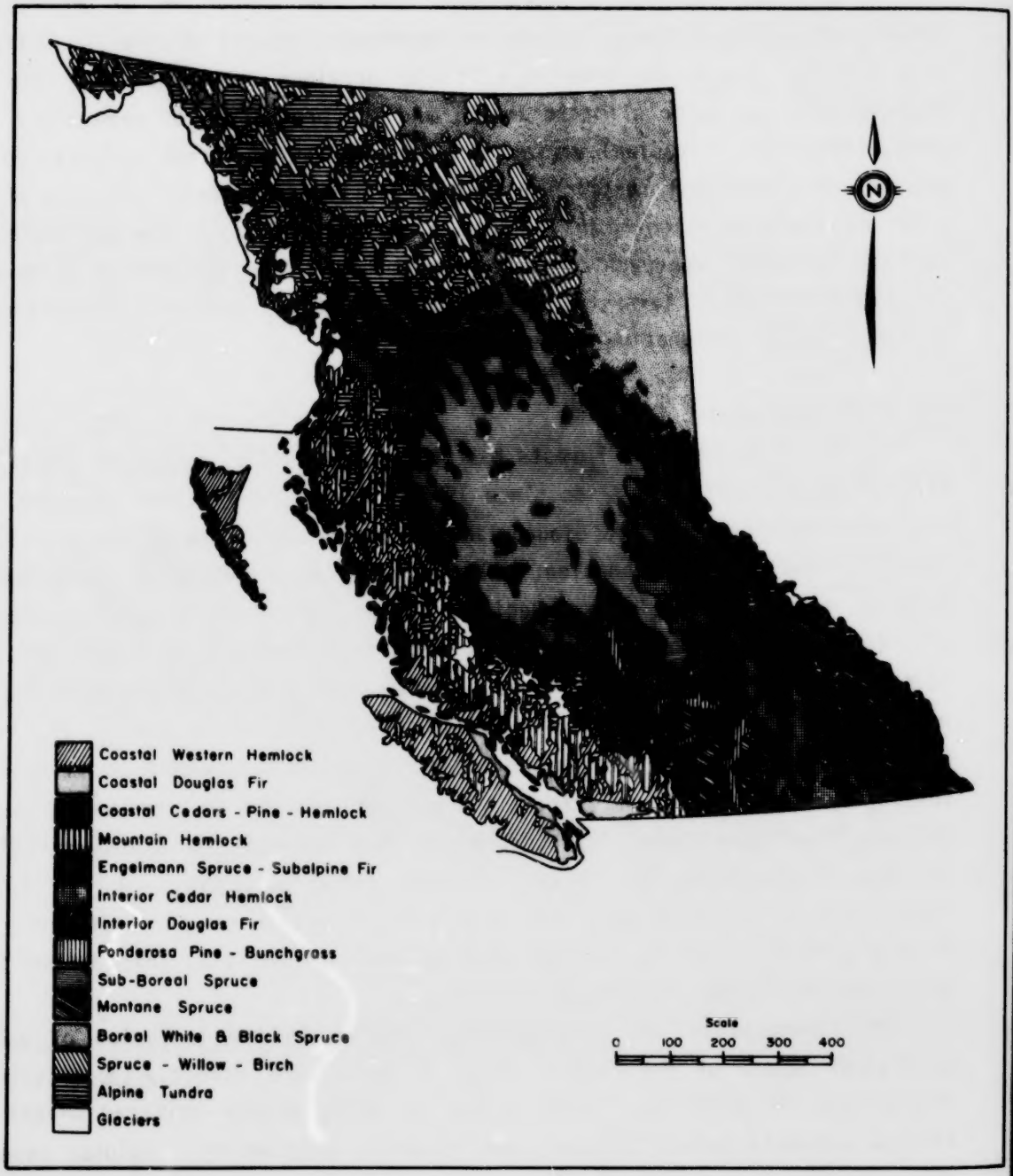


Figure 21. Biogeoclimatic zones of British Columbia (B. C. Ministry of Forests, Research Branch 1980).

formation, seven of which are described for British Columbia (Krajina 1965). However, these still tend to be altitudinal bands. A possible alternative has been described for two Forest Regions (Kamloops and Nelson) in which climatic regions are described that encompass varying combinations of biogeoclimatic zones and subzones. This alternative has been used as a means of setting geographic boundaries for publications on ecological classification (R. Mitchell, pers. comm.).

6.2.5 Biophysical Vegetation Regions

The biophysical vegetation classification program has been carried out by the Terrestrial Studies Section of the Ministry of Environment. This program differentiates and classifies ecologically significant segments of the land surface, using a system reflecting ecological processes. The classification system is hierarchical, with several different parameters being emphasized at different levels. Biophysical vegetation regions, at the upper level of the hierarchy, place major emphasis on macroclimatic parameters. A region is defined as an area in which the broad regional climate and physiography determine the definitive vegetation pattern (Harcombe 1981a). Vegetation regions have been delineated at a small scale for most of the province; level of detail and accuracy varies depending upon available data (J. van Barneveld, pers. comm.). Six vegetation regions have been designated (Figure 22). There are similarities between biophysical vegetation region lines and those of the wildlife ecosystem regions - this is to be expected because of similarity in approach and emphasis.

Advantages and disadvantages of this system are similar to those discussed for biogeoclimatic zonation. Unlike the biogeoclimatic system, the biophysical vegetation region encompasses a series of related horizontal zones of vegetation that tends to include home ranges of larger mammals. Though this inclusion is not a designated parameter of the vegetation classification, it will apparently incorporate most animal home ranges. Two disadvantages of the biophysical system are 1) the lack of present effort in refining and updating the distribution of these units, and 2) the low level of use of this level of the biophysical program.

6.2.6 Forest Regions

Forest regions have been described and mapped for Canada by Rowe (1959; 1972). They are not part of a classification, since categories were not based

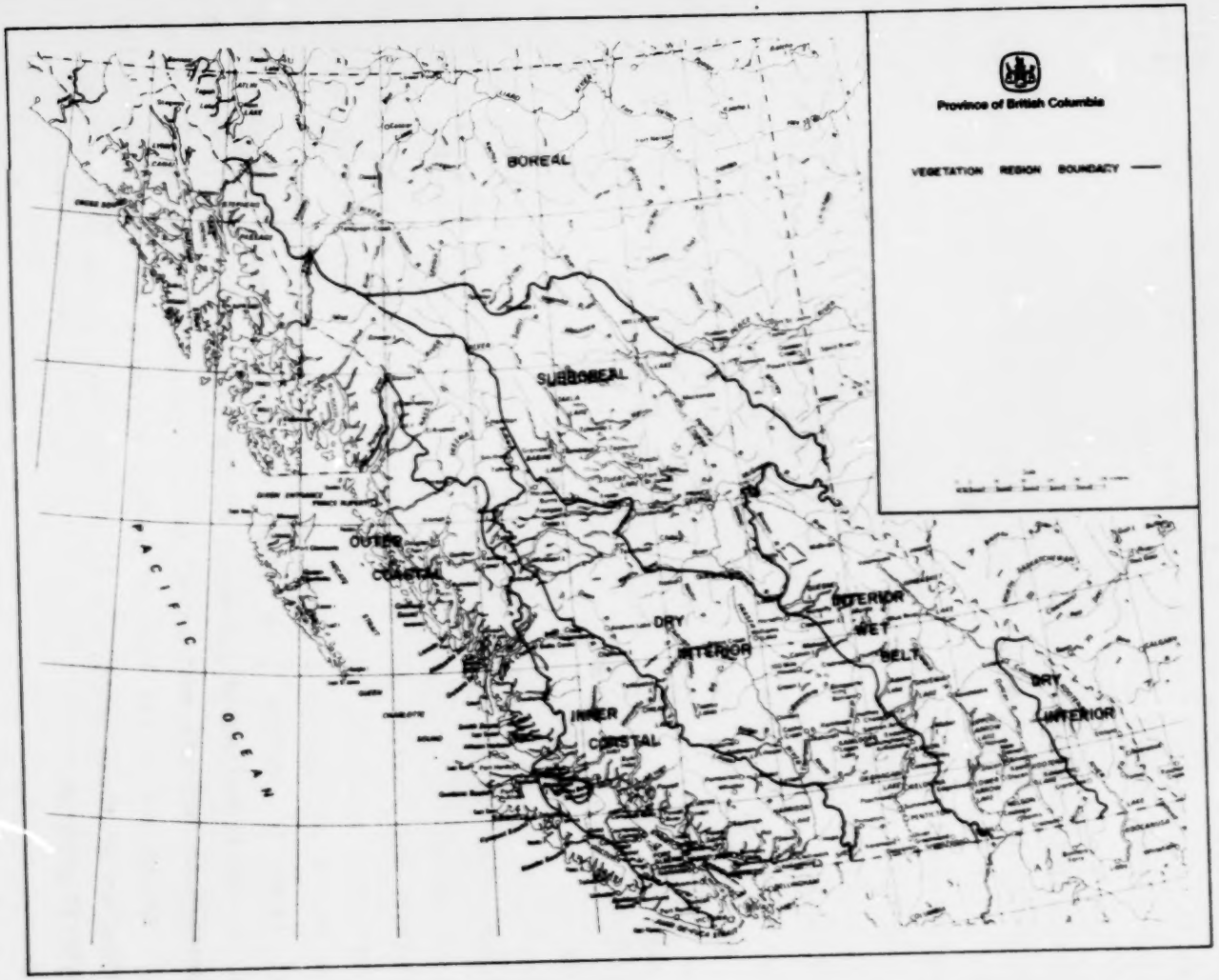


Figure 22. Biophysical vegetation regions of British Columbia (preliminary draft) (from B.C. Ministry of Environment, Surveys and Resource Mapping Branch 1982)

on consistently applied criteria (Rowe 1959:7). Regions are large units of forests described as stable, climatically controlled formations characterized by the presence of certain climax-dominant tree species. Forest Sections are defined as subdivisions of the Regions, conceived as "a geographic area possessing an individuality which is expressed relative to other Sections in a distinctive patterning of vegetation and of physiography" (Rowe 1959:8). The section is usually of large areal extent and more or less heterogenous. The criteria for the description of the boundaries are macro-features of the vegetation, such as distribution, life-forms, physiognomy, and patterning of the total vegetation. Eighteen Sections in five Forest Regions are mapped for British Columbia plus Grassland and Alpine Tundra (Figure 23).

Disadvantages of this system for delineating handbook areas are similar to those for the biogeoclimatic system; in addition, the forest region designation is not a classification per se and has not been utilized to any great extent in British Columbia for anything other than broad vegetation descriptions of particular geographical areas.

6.2.7 Ecoregions

Bailey and Cushwa (1981) have produced a map of ecoregions of North America, based on earlier work by Bailey (1976) and Crowley (1967). This system has four levels of classification: a domain, which is a subcontinental area reflecting broad climatic similarity; a division, which is a subdivision of a domain reflecting vegetation, regional climates, and zonal soils; a province, which is a subdivision of a division reflecting soils, with a single climax plant association; and a section, which is a subdivision of a province reflecting local climatic variation. British Columbia has two domains with seven provinces (see Figure 1 and Table 1). For a handbook area, only the upper three levels would be considered, since only these are mapped.

One advantage of this approach is that it provides a compatible link with the rest of North America. Several of the U. S. handbook efforts crosswalk their classifications to Bailey's ecoregions. The approach is based on a range of parameters that have some direct relationship with animal habitat needs. There are only a few units, keeping down the number of potential handbooks. A major disadvantage is the lack of any zoological input; there is no implied homogeneity of general animal behavior within units, though there is a strong likelihood it exists. There is a lack of use or familiarity with the system by provincial resource agencies. There are also some strong doubts as to the

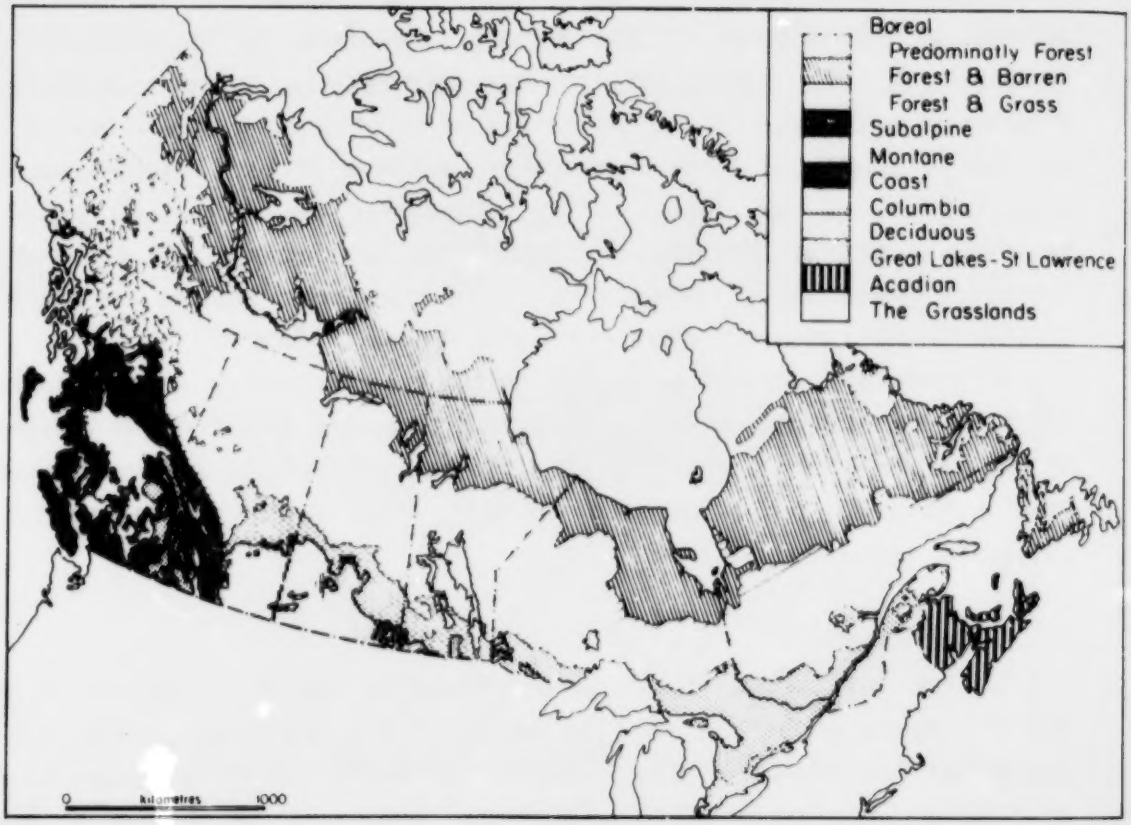


Figure 23. Forest regions of Canada (after Rowe 1972).

accuracy of the data used to map lines in British Columbia (D. Demarchi, pers. comm.), though this is not a conceptual disadvantage.

6.2.8 Administrative Units

Both the Ministries of Environment and Forests have administrative units within which they operate many of their programs. Environment has eight regions (Figure 2) within which there are 41 strategic planning units. Forests have six regions (Figure 4) with their major planning effort being directed within about 35 Timber Supply Areas (Figure 5) and Tree Farm Licences.

Use of these units would be simplest for managers and planners to use. However, there are several disadvantages to using these units as handbook areas. Units differ between government agencies. Boundaries are subject to change for purposes unrelated to wildlife or the natural landscape[1]. Other Ministries are currently modifying their regional structure.
There is no inherent relationship between animal behavior and the administrative units, and there is no strong correlation between the units and ecological, climatical, or topographical homogeneity.

6.2.9 Discussion

It would be a formidable task to assemble a large number of species - habitat model sets. In actual fact, whatever the final split of the province, a flexible format would allow accumulation of the information into any number of different combinations, crosswalking the information to any desired unit of classification. Initially matching the handbook to some form of ecologically based classification should prevent unnecessary duplication of effort. Handbooks in the United States have averaged 20-25 habitat classes per project (H. Salwasser, pers. comm.). The broader the geographical area, the broader the habitat classes. Bailey and Cushwa (1981) have mapped ecoregions for all of North America - these ecoregions are arranged hierarchically: domain, division, province, section, district, etc. Within divisions for British Columbia, there is some differentiation based on gross physiography - plateaus and mountains. Their seven provinces appear to reflect a suitable breakdown of British Columbia into manageable units. A similar philosophy of approach has been followed in the wildlife ecosystem region project (Demarchi and Pendergast 1983), except that the larger scale of mapping has resulted in better detail

---

[1]At present (September, 1983) there is a process underway to reduce Ministry of Environment regions from eight to five by early 1984 (W. Kastelen, pers. comm.)

and more refined units. However, the biotic region units are not grouped hierarchically, so broader levels of generalization and the accompanying accumulation of data at a broader level was not incorporated into the wildlife ecosystem region project.

6.2.10 Recommendation

The present level of detail for wildlife ecosystem regions and subregions may be suitable for matching species biology of ungulates to habitat characteristics. For the majority of species, this level is more detailed than necessary. Demarchi (pers. comm.) and this author have tentatively proposed a grouping of the wildlife ecosystem regions and subregions into eight units or handbook areas, illustrated in Figure 24. These units are not entirely satisfactory from a pure hierarchical viewpoint, since splits have been made within regions (see Table 11); however, these eight appear to be the author's best choices.

Production of the first set of handbook products is recommended for the Thompson Plateau wildlife ecosystem region and the Okanagan Ranges wildlife ecosystem region (regions 10 and 11 on Figure 19, Figure 25): the Southern Interior habitat handbook. The major advantage of this choice is that as well as representing some wildlife distribution integrity, it closely resembles the dry and very dry climatic regions of Mitchell and Green (1981), so there is a strong correlation of the wildlife ecosystem region to biogeoclimatic units.

As the handbook outline is proposed in detail in Chapter 8, much of the handbook content need not be repeated for each handbook area. The species-habitat models (lowest level) will be the major repetitive effort to follow the proposed handbook areas; other chapters may be repeated or rewritten for a subset of the nine choices.

6.3 Authorship: Preparation of Handbook Components

6.3.1 Discussion

One of the two authorship concepts deals with the actual preparation and writing of the various handbook components. Criteria for deciding authorships (competence is assumed) should include:

1) widespread distribution of the writing; because of the scope of the proposed project (see Chapter 7), the work load of writing must be

Table 11. Grouping of wildlife ecosystem units in proposed handbook areas

Handbook Area	Wildlife Ecosystem		
	Region		Subregion
A (Inner Coastal)	Georgia Depression	(1)	A, B, C
	Fraser Lowlands	(3)	A, B
	Pacific and Cascade Ranges	(4)	A
B (Outer Coastal)	Vancouver Island Mountains	(2)	A, B
	Pacific and Cascade Ranges	(4)	B, C
	Kitimat Ranges	(5)	A, B, C
	Queen Charlotte Islands	(6)	A, B
	Queen Charlotte Lowlands	(7)	
	Hazelton Mountains	(8)	A
C (Southern Interior)	Okanagan Ranges	(11)	
	Thompson Plateau	(12)	A, B
D (Cariboo-Chilcotin)	Chilcotin Ranges	(13)	
	Fraser Plateau	(14)	A, B, C
E (Fraser-Nechako)	Hazelton Mountains	(8)	B
	Nass Basin	(9)	
	Fraser Basin	(15)	A, B
F (Northern Mountains)	Boundary Ranges	(10)	A, B, C, D
	Skeena and Omineca Mountains	(16)	A, B
	Northern Mountains and Plateau	(17)	A,B,C,D,E,F
	Hart Ranges	(21)	A, B
	Northern Rocky Mountains	(22)	A, B, C
G (Columbia and Rocky Mountains)	Columbia Mountains & Highlands	(18)	A, B, C, D, E
	Southern Rocky Mountain Trench	(19)	A, B, C
	Southern Rocky Mountains	(20)	A, B, C
H (Peace River)	Alberta Plateau	(23)	A, B, C, D

Figure 24. Proposed wildlife habitat handbook areas for British Columbia. Area 1, the Southern Interior, will be the pilot project area.

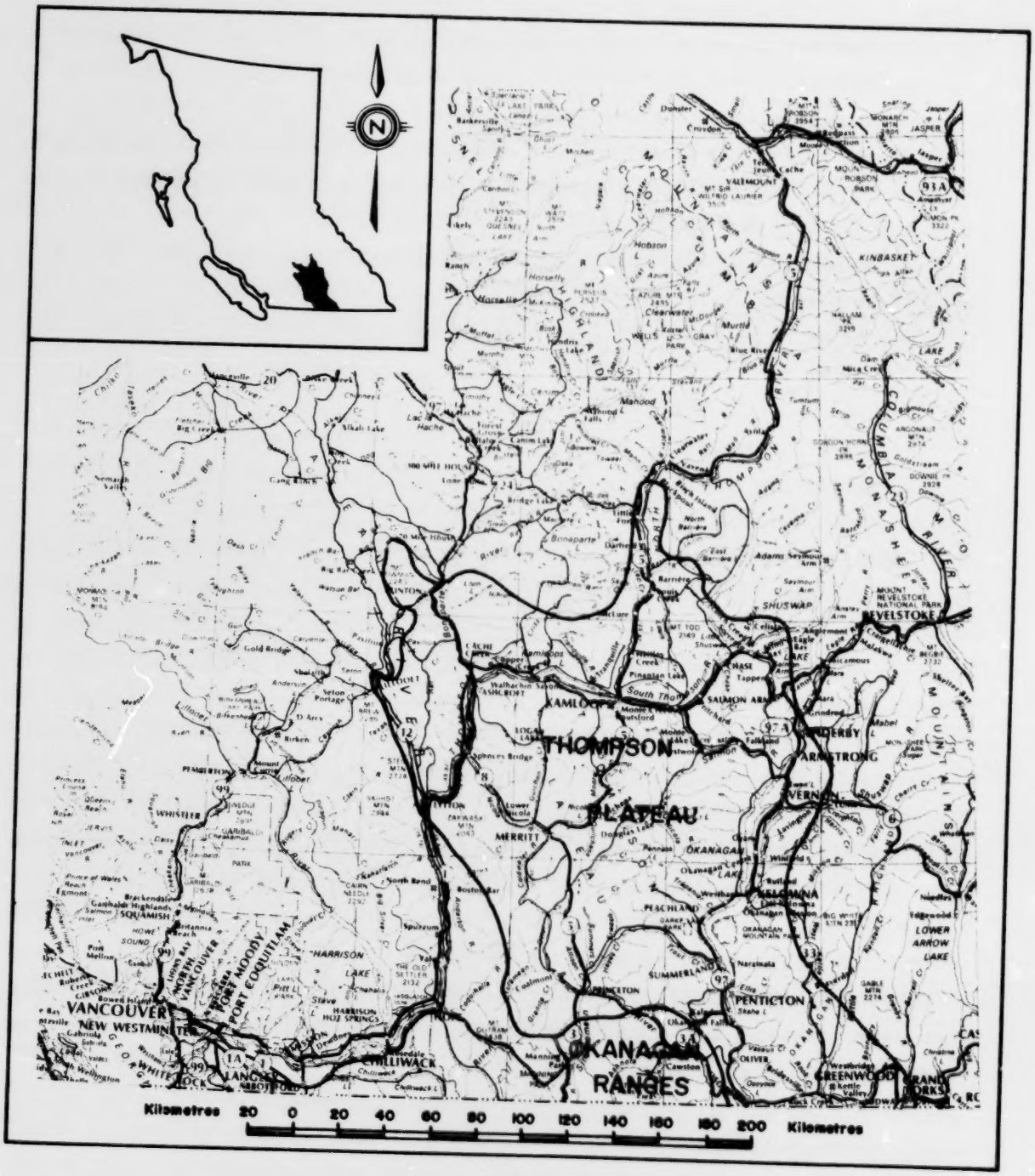


Figure 25. Proposed pilot project area: the Southern Interior.

distributed to as many people as necessary that are capable of providing appropriate inputs;

2) there must be definite commitments by authors to provide products by predetermined deadlines. These commitments must be supported by senior managers in the agency; and,
3) determination of authors and sequence of authorship should be based on contributions to conception, design, and manuscript preparation (Dickson and Conner 1978).

A number of options for handbook preparation can be used, including writing being done:

1) all internal to government as time allows;
2) all internal to government with definite committment;
3) all contract writing;
4) by a combination of 2 and 3; and,
5) all by one person.

Using government staff has a number of advantages. There is an allowance for onstream modification based on findings to date; it is easier to receive direct input from more people; and control is direct. The second approach, to contract out the information gathering after the desired products are clearly defined and specified, may result in a more rigid following of the initial rules, with little flexibility for modification; it may restrict the possibility of maximizing available professional opinion and knowledge. A majority of the resource specialists in British Columbia work for the provincial government; access to them and to their data is streamlined by interchange with other government employees. The approach to authorship of utilizing these people directly in a cooperative venture allows for greater involvement of the intended users at an early stage of the project. Thomas (pers. comm.) stated that building with "local ownership" is an advantage in convincing the people that later utilize the product as to its usefulness. This can result in a tremendous saving of implementation effort.

6.3.2 Recommendation

The memorandum of agreement (Appendix 11.1) has provided the project with a commitment of cooperation and input from the major resource groups. It is recommended that the the best alternative for authorship of the B. C. handbook is by assignment of the various topics to individuals or small groups of

government (and university) personnel, after receiving some assured priority status regarding completion of these inputs on an agreed schedule. A project coordinator will provide overall coordination of subprojects (see Section 6.4). For completion of the actual species-habitat matrices, it is recommended that authorship is looser, with an effort to synthesize the collected wisdom of as many resource professionals as possible.

For each species or group of similar species (either taxonomic or guild), relevant literature is first perused and summarized by individual workers and then synthesized by a specialist group which adds information or makes refinements to the data base to achieve the best possible product. The initial pilot project should set the guidelines for other handbooks.

6.4 Authorship: Coordination and Technical Editing

6.4.1 Discussion

The second concept of authorship deals with coordination and technical editing of the handbook. Criteria of importance to decisions for these roles are:

1) control of the final product must enable decisions to be made without large committee-style discussions once the overall direction is in place; the coordinator(s) or editor(s) must have editorial control over the various authors (J. W. Thomas, pers. comm.).
2) the role and rights of the technical editor(s) should be predetermined to "prohibit unauthorized or unethical use of data and should enhance maintenance of professional ethics" (Dickson and Conner 1978).

There are a number of options available for the role of technical editing/coordination:

1) one person, with final responsibility ("dictatorial" control);
2) a small group, with a "triumvirate dictatorship"
3) committee democracy;
4) no editing or coordination.

With the wildlife-habitat relationships products in the United States, there is usually one or two technical editors or coordinators with almost dictatorial control over the products (J. W. Thomas, pers. comm.). This has been found to be necessary to achieve their objectives within a reasonable amount of time. For British Columbia, a number of handbooks are planned after the initial pilot project. Sharing the technical editorship among more than one person will provide a better opportunity for maintaining continuity with these future handbooks.

6.4.2 Recommendation

It is assumed that overall policy and direction will be controlled by the provincial coordinating committee (see Appendix 11.2). However, it is recommended that a combination of options of a small "triumvirate dictatorship" and one person be followed for technical editing and coordination of the pilot handbook. This group should have the final say in items such as format, scope of content, and general editorial continuity; the review of the actual content for the various handbook components should remain with the expert reviewers. It would be a major function of the editing group to keep the handbook preparation on schedule, intervene if problems arose within each component group of authors, and generally keep the project operating smoothly. For the pilot project, a single coordinator, with two technical editors, are recommended. A. Harcombe would be the coordinator and editor-in-chief, while D. Eastman, and R. Ellis would be technical editors, with liasion with their respective regional ministry staff. The overall arrangement is summarized in Figure 26.

6.5 Presentation Opportunities

6.5.1 Discussion

The following three criteria should be considered in choosing a presentation format for the handbooks:

1) ease of updating or modifying
2) ease of access to information by users
3) minimum time delays in making information available.

There are four options for presentation formats of the wildlife habitat relationship information. They are:

1) a single, high profile handbook;
2) a set of publications, each representing a chapter of the handbook;
3) unpublished xerox publication (often kept in a ring binder); or
4) the level 1 species-habitat matrices on a computer data base only.

Thomas' (1979c) Blue Mountains handbook is an example of a high profile, single volume handbook that includes both species-habitat matrices and special management chapters on featured species and habitats. An advantage of this publication is its high visual impact, its wide distribution, and its completeness as a total package of necessary information. Disadvantages include delay in publication until all chapters are finalized and ready, inability for updating or modifying the data base, and an inability for extraction (except

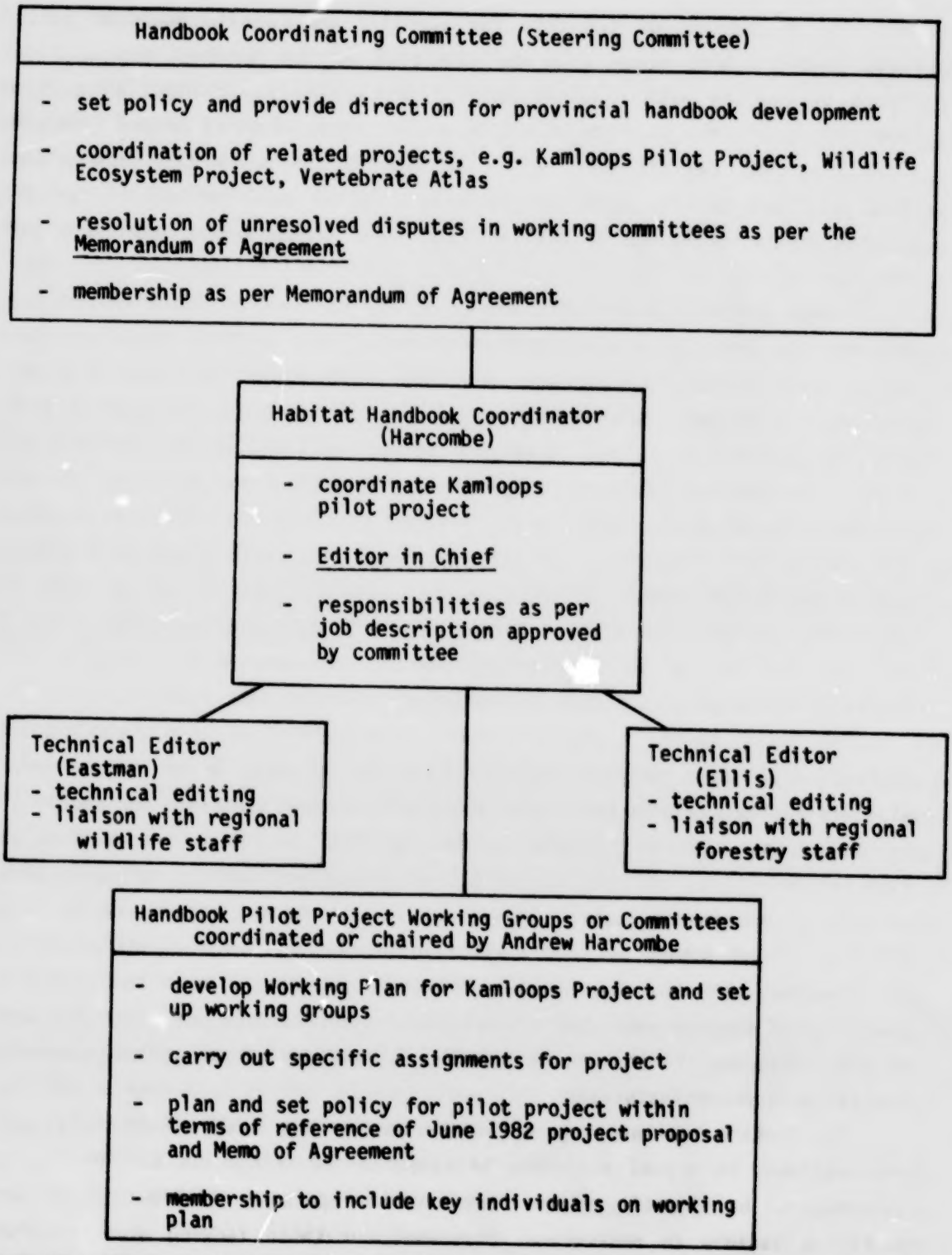

Handbook Coordinating Committee (Steering Committee)
- set policy and provide direction for provincial handbook development
- coordination of related projects, e.g. Kamloops Pilot Project, Wildlife Ecosystem Project, Vertebrate Atlas
- resolution of unresolved disputes in working committees as per the Memorandum of Agreement
- membership as per Memorandum of Agreement
Habitat Handbook Coordinator (Harcombe)
- coordinate Kamloops pilot project
- Editor in Chief
- responsibilities as per job description approved by committee
Technical Editor (Eastman)
- technical editing
- liaison with regional wildlife staff
Technical Editor (Ellis)
- technical editing
- liaison with regional forestry staff
Handbook Pilot Project Working Groups or Committees coordinated or chaired by Andrew Harcombe
- develop Working Plan for Kamloops Project and set up working groups
- carry out specific assignments for project
- plan and set policy for pilot project within terms of reference of June 1982 project proposal and Memo of Agreement
- membership to include key individuals on working plan

Figure 26. Proposed authorship: coordination/technical editing framework for the pilot habitat handbook (B. Pendergast, pers. comm.)

manually) of subsets of the data for specific areas. It should be kept in mind, however, that since this well-designed, glossy document was a pioneer effort of dealing with wildlife habitat and forestry interactions, it was important to achieve maximum impact on a wide range of users beyond those that might use that specific data set. The Blue Mountains handbook has achieved this goal far beyond projected success; future publications in the WFHR program are unlikely to be published to this standard (H. Salwasser, pers. comm.).

Thomas and Maser (1979-1983) are presently working on a multi-volume handbook for the Great Basin rangelands of Oregon. This handbook project is similar in topic content to the Blue Mountains publication, but each chapter is published separately, with no use of color. An advantage of this format is that the information is made available as soon as it is ready, changes can be made to portions of the publication without affecting the rest, and additions to the handbook (e.g. additional featured species) can be easily provided. The species-habitat matrices are being produced separately and are available to a more restricted number of direct users. There appear to be no major disadvantages of this publication format approach providing the species-habitat matrices are updated as more information becomes available. There is not, however, any computer-assisted extraction of specific data sets.

The Rocky Mountain region of the Forest Service (U.S. Department of Agriculture, Forest Service 1981k, 1981l) has produced a two volume set of wildlife-habitat relationships products. These are presented as photocopies in three-ring binders. These volumes present the data information only (species narratives and species-habitat matrices), and do not include chapters on special management topics; they are similar to the appendices in Thomas (1979c). An advantage of this publication format is low cost and possibility of updating the data by simply replacing pages. Disadvantages are the inability of computer-assisted extraction of specific data sets, the low impact on new users, and the absence of detailed discussions of management options and special management features.

The Montana habitat program has the entire data base on computer, but is not available in a published form (Prather and Burbridge n.d.). This has the advantage of being easily updated but has the important disadvantages of being poorly accessible to nonregional personnel, or those lacking experience with computers with no visual impact to new users, and no detailed discussions of management options and special management features.

6.5.2 Recommendations

Without a detailed consideration of cost as a factor of publication format, a combination of the format used in the Great Basin and the Rocky Mountain region is recommended. Each chapter would be published separately but amalgamated into three-ring binders for consolidation of the data package - the species-habitat matrices would be available on a computer data base as well as in hard copy appendices in the binder. This is a similar approach to that taken for the habitat capability reports published by the United States Fish and Wildlife Service (U. S. Department of the Interior, Fish and Wildlife Service 1980a; 1980b; 1981). Each chapter, after it is written and edited can be printed and distributed. The binder format allows the information to be kept together as a single package. Different handbook areas might have different combinations of chapters. Species-habitat matrices would be published as separate appendices for different handbook areas. Since the data would be in a computer data bank, it could be edited, updated, and made available in whatever combination was desired.

6.6 Requirements for The Wildlife Habitat Handbook

The second consideration for the British Columbia wildlife habitat handbook is the actual content. This includes the needs of knowledge organization prior to the handbook preparation and the ways in which relationships of species to habitat and associated management activities are determined. The content options and recommendations are presented in the following pages (summarized in Table 12).

There are often attributes of the species themselves that may be important in the evaluation of habitat manipulation impacts. These may be behavioral characteristics or attributes of species distribution or life history needs. Many of these data could not be considered in a standarized model for all species; their importance however should ensure their availability to the planner or manager. In the United States this need is covered by species notes (Salwasser *et al.* 1980) or species narratives (see Section 6.5.2).

There may be a need for a number of different levels of species-habitat relationship models, ranging from the basic level applicable to all vertebrate species (e.g. Thomas [1979c] appendices) to levels of greater detail and objectivity (e.g. habitat suitability indices [Schamberger *et al.* 1982]). These models will be simpler to use if definitions and options remain as

constant as possible as detail is increased. By classifying habitat with a hierarchically related system, different levels of detail may be selected at different levels in the hierarchy, without a complete system change and without loss of information from less detailed levels. At the same time, the number of attributes needed to evaluate habitat for a species should be kept to a minimum needed to perform a reliable evaluation; chosen attributes should be used as surrogates of other attributes where possible.

There are two approaches to managing wildlife habitat through the use of species-habitat relationships. One approach is to evaluate, at a planning level, the impact on habitat of the entire list of vertebrate species, using the broad level of species-habitat relationshuip matrices (e.g. Sheppard et al. 1982), and only examine in detail a few featured species whose populations should be increased (e.g. mule deer and elk in the Blue Mountains [Thomas 1979]). The second approach is to choose a select list of species and habitats that can be managed to achieve both species richness and featured species management goals. This approach utilizes a list of management indicator species or habitats that are examined at appropriate levels of detail, under the assumption that other non-listed species will be adequately managed if the objectives for MIS are achieved.

To provide a basis for a complete species-habitat relationships program for the management of wildlife in British Columbia, there are three requirements that have been consistently utilized in similar programs.

1) a set of information common to each wildlife species, to provide basic data for models, information on species ecology and distribution, and references for additional information needs of management or planning, in the form of species notes;
2) a basic wildlife-habitat model, utilizing selected habitat and natural history attributes, for all vertebrate species for use in species richness management, and;
3) detailed wildlife-habitat models, with additional detail on habitat management alternatives, for selected species and selected habitats.

The following sections are a discussion of evaluation criteria, options or opportunities, and recommendations (where possible) for the aforementioned three categories of wildlife-habitat relationship needs. Though recommendations may be similar to those chosen for the WFHR program in the United States, they have been considered within the framework of the British Columbia environ-

ment and management systems. These content criteria, options, and recommendations are summarized in Table 12.

6.7 Species Notes

6.7.1 Discussion

The basic criterion for species notes is that they contain information relevant to all levels of species-habitat models, including:

1) taxonomy (probably to the subspecific level);
2) status and abundance: official status (e.g. endangered) and abundance and seasonal activity (e.g. common permanent resident, rare winter resident, abundant migrant) for British Columbia;
3) distribution/habitat: distribution map, cross references to a number of classification schemes (e.g. administrative units, latitude-longitude, national topographical system of mapping), and direct tie to habitat classes for British Columbia;
4) special habitat requirements: specific habitat elements that enhance habitat classes for use, as well as critical components needed for evaluation of impact of management activities;
5) breeding: information on reproductive site, basic reproductive data (e.g. age of sexual maturity, number of clutches or litters per year, average number of offspring per reproductive event, length of gestation or incubation period, length of fledging or weaning period, length of further dependency), reproductive season;
6) territory/home range: sizes and minimum habitat sizes;
7) food habits: foraging strategies and diet elements;
8) other notes: as applicable; may include special implications of management activities, etc.;
9) references: selected references for additional information, more detailed data, etc.

One alternative for producing species notes (equivalent to species narratives for some WFHR programs) is to coordinate the handbook needs with the "Atlas of British Columbia Vertebrates Project", currently coordinated by the Vertebrate Zoology Division of the British Columbia Provincial Museum, Ministry of Provincial Secretary and Government Services. These atlases will provide information on the distribution, occurrence, and selected natural history topics concerning mammals, birds, reptiles, and amphibians for all of British

Table 12. Criteria, options, and recommendations for content

Subject	Criteria	Options	Recommendations
Species Notes (Section 6.7.2)	1) contain information on: taxonomy, status, abundance, distribution, habitat, special habitat habitat requirements, breeding, territory/home range, food habitat	1) modify "Atlas of B. C. Vertebrates Project" (Provincial Museum) to supply information 2) prepare species notes as part of the handbook project	encourage modification of "Atlas" to ensure requirements of species notes be met
1. Species-habitat model A. Habitat Classification (Section 6.8.2)	1) match scales with that of users 2) be mapable 3) include attributes of specific importance to wildlife habitat interpret 4) simplicity 5) direct connection to management activities 6) reliable linkage of species use to habitat 7) variables must be based on causative factors	1) biophysical vegetation classification system 2) Forest Service ecological classification system 3) forest cover inventory mapping system 4) combination of above	combination of options using mapping approach of biophysical system but maintaining strong links to other two systems
2. Successional stages (Section 6.8.2.6)	1) reflect structural changes that are of significance to wildlife	1) arbitrary divisions 2) interpretive divisions based on major changes in structure	forested communities: grass/forb, shrub/seedling, pole sapling, young seral, mature seral, climax shrubland communities: grass/forb, low shrubs, high shrubs, shrub/tree herbaceous communities: grass/forb
3. Canopy closure (Section 6.8.2.8)	1) should reflect changes that are of significance to wildlife (food or shelter)	1) arbitrary divisions 2) interpretive divisions based on significant changes in habitat resources for wildlife	0 - 25% sparse cover 26 - 65% moderate cover 66 - 100% dense cover
B. Specific habitat elements (Section (6.8.3)	1) must be used by wildlife to support life requisite 2) essential or preferred presence necessary to achieve highest capability for habitat	1) short, general list 2) detailed list of all possibilities	detailed list, to include diet items, "substrates" used for feeding, reproduction "substrates", cover "substrates"
C. Life requisites (Section 6.8.4)	1) must reflect a direct contribution to either survival or reproduction of the species	1) feeding 2) reproduction 3) shelter cover 4) escape cover 5) water 6) special needs 7) combination	feeding, reproduction, special needs
D. Capability coefficients (Section 6.8.5)	1) preferrable to have a proportional or ordination scale 2) must be measurable	1) presence/absence 2) MDE wildlife capability classification 3) probability of occurrance 4) recruitment 5) combination	modified MDE scale, in combination with probability of occurrence and recruitment

Columbia. The basic objectives are to extract and transfer natural history and distribution data from a wide variety of published and unpublished sources (see Table 3), maintain a provincial data bank where this information is consolidated, stored and easily retrieved, and prepare a summary map of distributions and pertinent natural history information to be produced in a series of four atlases: one for amphibians and reptiles, one for mammals, and two for birds (Campbell and Harestad 1981). Bibliographies are presently being produced (e.g. Campbell et al. 1979; 1982). References are indexed by species taxonomy, geography (two alternatives to date, in combination with National Topographic System on 1° latitude by 2° longitude grids), and author.

A second alternative to producing species notes is to prepare them as part of the wildlife habitat handbook program. This option would lead to considerable overlap between the Atlas and Handbook projects and a possible long delay in achieving handbook objectives.

6.7.2 Recommendation

Full support should be given the "Atlas of B. C. Vertebrates" program. The terms of reference for the natural history notes of the Atlas should be encouraged to be expanded in cooperation with the habitat handbook project to ensure that the requirements for the species notes are met. This is especially true for habitat-related comments, where the same classification and terminology should be maintained.

6.8 Wildlife-Habitat Relationships

6.8.1 Discussion of Wildlife-Habitat Relationships and the Basic Models

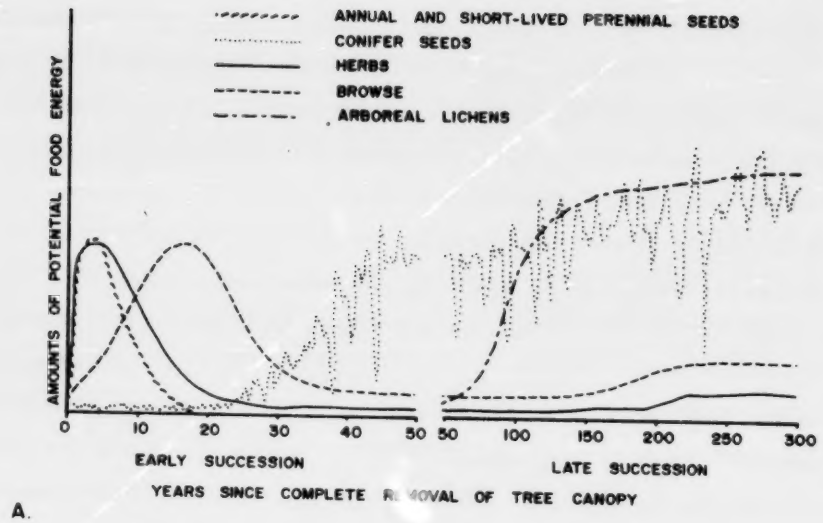
Wildlife are products of their total environment: habitat, weather, predators, competitors, disease and the population itself all act upon the wildlife population (Salwasser and Unkel 1981). Habitat is considered to be the key to organizing knowledge about wildlife so that it can be used in management of forest or range because maintenance of appropriate habitat is the foundation of all wildlife management (Thomas 1979b). By considering the habitat as the prime determinant of wildlife welfare and then associating wildlife with habitat condition, impacts of land management activities on wildlife can best be interpreted (Thomas et al. 1979e). The premise that habitat is the "common ground" for an interacting system between wildlife and other resource manipulations places great importance on choosing a model of wildlife-habitat

relationships that is both valid for wildlife and at the same time can be related to the various land management activities.

Bunnell and Eastman (1976) described a general model for the influence of forest management practices on wildlife. Though it might not have been their intention, the rationale and concepts discussed in this model form a strong justification for the present direction of the wildlife-habitat relationships program in the United States. Much of the following discussion is synthesized from their paper; if no references are given, it should be assumed that Bunnell and Eastman (1976) are the major source.

There are six basic resources required by wildlife; energy, nutrients, water, temporary shelter (from wind, heat, or snow), habitation (dens and cavities), and antipredator cover and space. These needs are packaged in a wide range of combinations. Because land management activities, such as logging, dramatically restructure the habitat, the way in which these animals needs are packaged and distributed is altered. Natural succession after disturbance lends some predictability to the pattern in which the packages are available and where they occur. A model that links animals to various components of the habitat needs to consider both the amount and the vertical and horizontal distribution of ingested and structural resources. When these are related to changes over time in the same way that management activities can be linked to changes over time, one has a direct means of evaluating the impact of the activity on the needs of wildlife and therefore on the wildlife themselves.

Ingested resources (food) are energy, nutrients, and water. "Amounts of energy packaged in forms ingested by wildlife are postulated to follow predictable patterns" with time since the start of a secondary successional sequence (e.g. removal of tree canopy by logging or fire) (Bunnell and Eastman 1976:5). This pattern is illustrated in Figure 27. For some of the food packages (lichens, annual seeds, conifer seeds) quality is not greatly variable. For herbs and browse energy packages, crude fibre and nutrient contents vary with successional stage. Generalized models illustrating this relationship are difficult to generate because data are scanty. The third ingested package, water, may be influenced by successional change. However, it is postulated that the forested areas are generally sufficiently moist that amounts of water are not limiting other than to animals which may require water as a structural component of the habitat. Water availability is not strongly influenced by forest practices, though it may be by range practices.



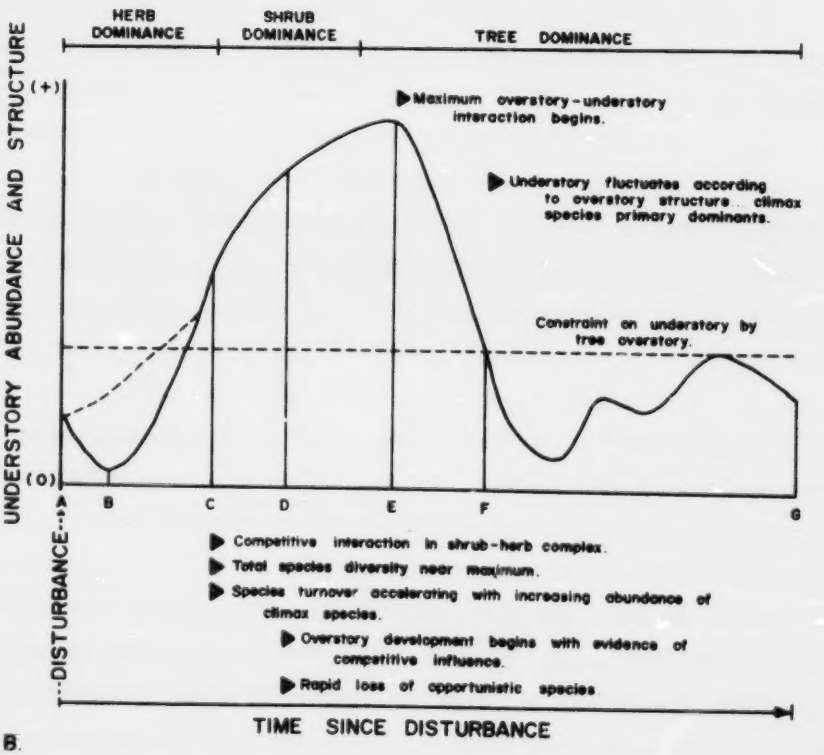


Figure 27. Changes in patterns in forest succession. A. Changes in amounts of potential food energy (from Bunnell and Eastman 1976). Production of conifer seeds is highly variable. B. Patterns of understory development (from Zamora 1982).

Land management activities directly influence amounts of structural resources (temporary shelter, habitation, antipredator cover, and space), except possibly geomorphic units like caves. The amount of temporary shelter varies with degree of crown closure. Crown closure is generally a predictable and manageable characteristic of vegetation succession. Temporary shelter requirements vary among animal groups.

Antipredator cover varies with time since the disturbance. Escape cover characteristics vary among animals. However, it is postulated that amount of escape cover increases more rapidly than does temporary shelter with successional progression.

Habitation types are very diverse. The pattern and number of nesting sites vary as forests age and differ according to species requirements. The forms of habitation often are components of the forest that are not tied directly to time since disturbance. The kind of disturbance may be of great importance for such habitation types as fallen logs and snags.

Wildlife species, especially birds, respond to the distribution of components of the habitat. This distribution of components or resources can be considered in both vertical and horizontal planes (i.e. alpha and beta diversity). The underlying postulate is that energy is the habitat resource that is most frequently limiting to wildlife populations, and home ranges or territories will be established in concurrence with long term averages of energy availability, maintained by behavioral responses. Vertical distribution of energy is postulated to have relatively strong relationships with stand age, mediated through the structural attributes of resources. Horizontal diversity seems not to be affected in a predictable way, and will be mediated through the energetic requirements of animal species. Land management practices that remove temporary shelter and energy sources such that they no longer occur in all individuals home range will disadvantage the species.

Vertical distribution of ingested resources and structural resources, though poorly documented, is postulated to be a function of stand structure succession, and/or crown closure, dependent upon the type of food or the ability of vegetation to provide shelter. Vertical distribution of habitation can be related to successional stage. As succession advances, so does tree canopy height and structural diversity to provide a greater diversity of potential niches. Escape cover is defined inadequately and is dependent upon type of danger and age class of animal. The significant measure is thought to be stand age (e.g. successional or structural stage).

It is important to study the relationship of each individual species to each attribute of the habitat, especially if one is concerned with species richness management; there are advantages therefore in describing habitats in categories by using a habitat classification (Thomas 1982). The discussion of a conceptual model of wildlife in managed habitats consistently identified three major attributes of habitat that could be modeled to predict quality of habitat for different habitat components. These are:

1) successional stage;
2) structure; and,
3) crown closure.

Other habitat attributes, such as topography, may be important but are not altered by land management activities. Salwasser et al. (1980) summarized the importance of habitat as a set of environmental elements by stating that "our ability to identify wildlife habitat improvement opportunities or to predict wildlife responses to management activities depends upon our understanding of how each species is related to the environmental elements that comprise its habitats, the current condition of those elements, and how they will change as a result of our activity or inactivity".

The habitation needs of wildlife are dependent upon detailed characteristics of the habitat (Bunnell and Eastman 1976); rather than attempting to make these attributes an integral part of a habitat class, they could be treated as additional "descriptors" of the habitat. This has been done by Salwasser and Laudenslayer (1982); the descriptors are called "specific habitat elements" and include specific information on both food and habitation needs.

The basic species-habitat model is the level of model that evaluates the elements of habitat for all species of mammals, birds, reptiles, and amphibians in the same manner. That is, the same categories of habitat are used for all the species ratings. Based on the available species/habitat relationships programs in the United States and the background discussion on species-habitat relationships of importance in British Columbia, there are five major categories of information that must be included in the basic species-habitat model for all species[1]:

1) habitat classification (e.g. habitat type, ecosystem association, successional stage, canopy closure, etc.); [see Section 6.8.2]

---

[1]"all" species does not include very rare, casual, or accidental occurrences within a handbook area unless the species is threatened or endangered.

2) special habitat elements that are not specific within the habitat classification but may be essential for habitat utilization by a species (e.g. presence of snags, fallen logs, edge elements, riparian inclusions); [see Section 6.8.3]
3) life requisite categories for separate evaluation (e.g. reproduction, feeding, cover); [see Section 6.8.4]
4) coefficients or ratings of value of the habitat class components or special habitat elements for providing the designated life requisites; [see Section 6.8.5], and;
5) season of use data to directly relate presence of species to management activities; [see Section 6.8.6]

6.8.2 Habitat Classification

6.8.2.1 Discussion

A habitat classification is needed that will adequately include information on the basic resources essential to wildlife plus have the ability to equate land management activities with natural successional changes through time. The basic resources essential to wildlife were discussed in Section 6.8.1; the most important attributes of habitat needed to describe these resources were concluded to be successional stages, structure and canopy closure. There is a strong underlying premise that wildlife often respond to structure more than to plant species composition, so habitat classes may be grouped or divided as structurally distinct and important habitats (Bunnell and Eastman 1976; Thomas et al. 1979e; Maser et al. 1982). Maser et al. (1982) claim that "the ability of plant ecologists to differentiate between plant communities exceeds the present ability of wildlife biologists to detect differences in animal communities". If wildlife biologists cannot demonstrate differences in animal communities between structurally similar plant communities, they should be combined.

In the species-habitat models, the habitat classification system is the key link among the different resource plans and management systems. In a proposal for a habitat classification that would include fish, a number of anticipated benefits of an ecological classification were listed (Anonymous 1982) that are applicable for the British Columbia project. The classification should:

1) provide an effective system for making wildlife resource assessments needed for broad and specific planning levels;
2) provide uniformity and consistency of approach from one area to another;
3) have a classification hierarchy that allows questions to be answered at many planning levels;
4) allow existing inventory information to be utilized initially, with enough flexibility to allow for revision as monitoring and research indicate, and;
5) provide an ecologically sound basis for organizing data that will provide the means for making reliable biological assessments.

These desirable features should be met if certain criteria are utilized in the selection of a habitat classification. One criteria is that scales should be matched. The scale or level of detail of the species-habitat data must be compatible with that used in both the Ministry of Environment and Ministry of Forests. Within the Ministry of Forests, this should include consideration of timber inventory units, ecosystem association units, and range inventory units. If the habitat classification can be suitable or useable at a number of different scales, then its usefulness is increased. For the purpose of the wildlife habitat handbook, wildlife-forestry and wildlife-range interactions are important in the planning process at subregional and operational planning scales. A hierarchical relationship of habitat units would allow a single classification to be used at both levels of planning and management. This would prevent the occurrence of two different classifications for different levels of species-habitat models, as occurred in Thomas (1979c); there, featured species used a land type classification and the basic, level one model for all species used a plant community classification. An emergent property of the wildlife-habitat relationships program in the United States is that, for whatever the chosen program area, the habitat classification results in 20-25 classes (H. Salwasser, pers. comm.). There should be compatibility of the chosen habitat classification with others utilized by the user groups; if not the same, at least the classifications should be matched or crosswalked. As well, use of existing inventory data would preclude a long delay in implementation of the species-habitat data.

A second criterion is mappability. The habitat classification should at least have the potential of being mapped, with units having measurable attributes. The classification also requires the units be identifiable at the

chosen scale, preferably at any time of the year, either by remote sensing and/or on-site. For the broad scale land planning (subregional), the habitat classification should be mapped. At the operational level, it may only need to be identifiable during on-site inspections by field staff. This operational-level criterion allows for greater detail of habitat that is more appropriate for featured species management, when the site characteristics of the environmental setting need more detailed consideration (e.g. browse species on a south slope for deer winter use might be critical for final assessment of land management impact, though at a broader scale the browse species may not be as important a determining attribute of planning for deer use). The value of an area as wildlife habitat "often depends on characteristics that are most easily interpreted from maps such as size, shape, and the attributes of adjacent units" (Stevenson 1982).

A third criterion is that the habitat classification must include attributes that have major impact on interpreting suitability and/or capability. If divisions of the classification do not contain specific attributes of importance, they should contain attributes that act as surrogates for that information. This criterion includes a need for divisions into successional or structural stages that will relate to changes created by management activities and a means by which changes through time can be anticipated. In combination with specific habitat elements (section 6.8.4), it is assumed that at least some of the attributes will limit capability of the habitat for wildlife species.

A fourth criterion is simplicity; the habitat classification should be no more complex than the level of biological knowledge for the majority of species contemplated at a particular level of the species-habitat model; otherwise the species to habitat relationships could not be assigned with a reasonable level of credibility.

The habitat classification must have some direct connection to management activities and effects of these activities. Units should be more or less homogenous in their response to manipulation; such units have been called treatment units. Management activities should affect the attributes described in the previous two criteria in a measurable fashion.

The habitat classification should result in a reliable linkage of species use to habitat classes and class components; the identification of confidence intervals would form a measure of information reliability.

The seventh and final criterion is that the classification variables should be based on causative factors of the ecological systems being evaluated

as habitat, based on relatively permanent natural features of the landscape; an integrated classification using these variables should have a wide range of interpretive potential.

There are a number of existing ecological classifications in British Columbia. Stevenson (1982) wrote an intensive problem analysis on applying ecological classification systems to wildlife research and management. The systems described were those used in the ecosystem classification program of the Ministry of Forests (roughly equivalent to biogeoclimatic classification), the biophysical classification program of Terrestrial Studies Branch, Ministry of Environment, and the soil-vegetation classification developed by Agriculture Canada. Stevenson (1982) stated that a classification system should:

1) be a natural ecological classification;
2) be applicable to large-scale mapping;
3) provide units that are homogenous in their response to forest management practices;
4) incorporate a mapping system that shows existing vegetation; and,
5) provide a framework for predicting structure and species composition of seral stages resulting from forestry practices.

Information needs were detailed and primarily assessed for deer and elk on Vancouver Island. The needs were related to habitat components (Coulombe 1978) and were at a level of detail somewhat equivalent to the treatment of featured species (deer and elk) by Thomas et al. (1976b). For example, Stevenson (1982) concluded species composition of understory was not adequately covered by a structural or successional attribute of a habitat class.

No clear decision was arrived at by Stevenson's problem analysis. The reviewed classification systems potentially collected the same data. However, Stevenson concluded that the success of the systems in meeting most of the general needs could not be evaluated "because of lack of information", though "modifications will be required" regardless of which classification system was chosen.

Some of the required needs of a habitat classification described by Stevenson (1982) are too detailed for the basic species-habitat model anticipated for the wildlife habitat handbook. Accepting the level achieved by the conceptual model developed by Bunnell and Eastman (1976) as a suitable starting point, the ecological classification options should be addressed as to their ability to provide information on habitat classes, successional or structural

subclasses, and canopy closure subclasses, and still meet the other stated criteria.

There are three main options for habitat classification using existing systems. Each of these is described in the following sections: biophysical classification system (section 6.8.2.2); Forest Service Ecosystem classification system (section 6.8.2.3); and, Forest cover inventory mapping system (section 6.8.2.4). In addition, two interpretive classifications are discussed: successional stages (section 6.8.2.5) and canopy closure classes (section 6.8.2.6).

6.8.2.2 Biophysical Vegetation Classification System (Ministry of Environment)

The biophysical vegetation classification is developed with a well-defined hierarchy of detail of biophysical units. The lowest level commonly mapped (scale of 1:20 000 - 1:50 000) is the vegetation landscape. Each vegetation landscape (formerly referred to as present ecological condition/expected climax units) represent areas that are relatively homogeneous with regard to soils, surficial materials, disturbance history, climate, and macro-vegetation. Each kind of unit represents ecological land segments that are relatively similar with regard to management alternatives, constraints to use, and production of major crops. Vegetation landscape units represent areas of similar soil texture, drainage, or landform over which similar trends of successional and climax vegetation should occur. Each map unit has vegetation landscape and successional stage identified. The successional stages are defined by plant community structure and plant competition relationships in the community; an approximation of this stage is determined from stand age and structure (Thompson et al. 1980). When successional stages are described for a landscape, the total potential sequence represents a secondary successional pattern (Harcombe et al. 1980); these should generally approximate the succession pattern that will occur after a "managed " disturbance as well as after a natural disturbance.

Vegetation landscapes can be grouped into the next level of biophysical vegetation units, the vegetation subzone. The vegetation subzone is an area in which the dominant vegetation (usually species composition of the tree canopy) of climax stands on similar soils and terrain is identical (Harcombe 1981a). Differences in climax vegetation within a subzone are due to physical site

differences and may be handled as climatic or edaphic vegetation landscapes. Subzones may be grouped into the next hierarchical level, the vegetation zone. Subzones within a single zone have similar dominant vegetation on similar soils and terrain, but are differentiated on the basis of climate-related successional trends or growth form of the dominant vegetation (Harcombe 1981a). For example, the Interior Douglas-fir zone has a climatic climax of Douglas-fir; after fire, drier parts of the zone may have ponderosa pine as the dominant seral species, whereas in cooler parts of the zone lodgepole pine may be the dominant seral species. This difference would be delineated at the subzonal level. Some vegetation landscapes may be similar between zones if site characteristics are different enough to influence vegetation more strongly than climate (e.g wetlands in depressional areas with high water-tables).

Vegetation zones may be combined into vegetation regions. The region is a geographical area in which the broad regional climate and physiography determine a definite vegetation pattern (Harcombe 1981a). A region may be subdivided into vegetation sections distinguished on the basis of variations in the vertical sequence of zones or subzones, or variations in the edaphic inclusions of zones.

Apparent advantages of this classification for use as a habitat classification are:

1) vegetation landscape classes are defined in such a manner that they are easily mapped;
2) successional stages (actual and potential) are described and actual stages mapped for each habitat class;
3) canopy closure, often added as part of the macrophysiognomic classifier of forested stages, may be easily modified and consistently applied from aerial photographs;
4) the classes are described using other ecological inputs, including climate, soils, terrain, and topography;
5) the classification is hierarchical;
6) the classification has been commonly mapped at different levels with scales ranging from 1:20 000 to 1:250 000, thus corresponding to the planning levels of concern;
7) the classification has been commonly used for wildlife habitat-related projects; and,

8) present inventory of data has followed standardized ecological data collection methodology.

Apparent disadvantages of this classification for use as a habitat classification are:

1) incomplete provincial coverage for lower levels of classification;
2) need for soils mapping to have been completed in conjunction with vegetation landscape mapping;
3) lack of common use by range or forestry planners or managers;
4) lack of correlation between the vegetation landscape level of description among project areas;
5) there is present policy (N. Sprout, pers. comm.) to do vegetation landscape mapping within the biogeoclimatic zonal framework; however, this does not take away from the value of the vegetation landscape/stage level, for habitat related projects.

6.8.2.3 Forest Service Ecosystem Classification System

The ecosystem classification system has two conceptual levels: biogeocoenotic and biogeoclimatic. The biogeocoenotic level deals with the classification of individual ecosystems; the biogeoclimatic level deals with the distribution of these ecosystems in relation to regional climate (Annas and Coupe 1979). Hierarchical relationships are present within both levels. The biogeoclimatic level is being mapped for the entire province, generally at a 1:250 000 or 1:500 000 scale. The biogeocoenotic level is rarely mapped. The ecosystem association[1] is the basic ecological category of the classification system; it is defined as a land area capable of producing plant communities with similar successional development, belonging to the same plant association at climax (Mitchell and Green 1981). The ecosystem association may be subdivided into functional phases based on differences in physiographic features, soil properties, parent materials, and/or bedrock geology. The major differentiating characteristics used are characteristic combination of species, soil characteristics, and associated environmental factors. These latter two characteristics are usually defined on the basis of soil nutrient and moisture classes, expressed on a two dimensional matrix called an edatopic grid.

---

[1]There is variation in terminology and definition between Mitchell and Green (1981) and the problem analysis of Stevenson (1982) who primarily used Vancouver Forest Region publications for her ecological classification discussion - Mitchell and Green (1981) is used for definitions for this report.

The ecosystem association considered to represent the intermediate characteristics of soil and site, with vegetation best reflecting the potential of the regional climate, is referred to as the zonal ecosystem association. This zonal unit is the link with the biogeoclimatic level.

The biogeoclimatic zone is defined as a geographic area with a broadly homogenous climate and patterns of ecosystems; it is characterized by closely related zonal ecosystem associations, climatic characteristics, and a unique characteristic combination of plant species (Mitchell and Green 1981). The zone may be subdivided into biogeoclimatic subzones, which are characterized by a single ecosystem association, climatic characteristics, and a unique characteristic combination of plant species. The biogeoclimatic subzone may be subdivided into variants, based on differences in climatic characteristics other than what is considered near average for the subzone. The current mapping program in the Kamloops Forest Region is mapping zones, subzones, and variants at the biogeoclimatic level.

Though the concept of succession is included in the ecosystem association, present emphasis is on forest stands in the maturing seral to young climax successional stages (80 to 150 years old).

Apparent advantages of this classification for use as a habitat classification are:

1) the classes are described using ecological inputs, other than just vegetation, including climate, soils, terrain, and topography;
2) present inventory of data has followed standardized ecological data collection methodology;
3) zonation mapping and ecosystem association characterization are being carried out in all British Columbia Forest Regions;
4) ecosystem associations are described for on-site identification;
5) the classification is hierarchical at two levels; and,
6) the classification is commonly used by forest planners and managers.

Apparent disadvantages of this classification for use as a habitat classification are:

1) ecosystem associations are not mapped except for occasional small special project areas;
2) zonation mapping is small scale only (1:250 000 to 1:500 000);
3) classification at lower levels are not commonly used for wildlife habitat-related projects;

4) classes are not defined in a manner for easy mapping;
5) successional stages[1] and opportunities are not described or mapped for each habitat class; and,
6) canopy closure is not part of the classification system, though it could be added as a modifier.
7) difficult to map ecosystem associations from aerial photographs

6.8.2.4 Forest Cover Inventory Mapping System

In the United States, the basic level of species-habitat model has used a habitat classification with a strong vegetation bias (see Section 4.6.2), dominated by a forest cover level of habitat class identity. Within British Columbia, forested lands are mapped by the Inventory Branch of the Ministry of Forests. Units of forest cover that are homogeneous for tree species composition, age, height, and stocking are delineated on aerial photographs. This typing is not truly a classification, though some conventions of labelling are utilized. Tree species must comprise at least 10 percent by volume of the stand to be included in the label. There are other conventions for number of species present in a label, application of stocking values, and the ordering of species. Height, stocking, age, and site quality are described by class. The maps are purely timber inventories displayed on a geographic base, with some land history applied (e.g. logging, fire). No ecological similarities between identically identified units is implied. However, crown land throughout British Columbia has been inventoried, with maps being drawn at a 1:15 640 scale (1 to 20 chain). Sites not forested may be designated as not satisfactorily stocked, etc. (if they have a potential for forest production) or placed in some broad category such as open range or alpine. Because these maps, cover such a large proportion of the province, they have been used for the presentation of some ecologically related interpretations. Environment Protection Areas (EPA's) are areas identifed as sensitive to forestry related uses - they may be on unstable soils, be important wildlife habitat, have high recreational use, or have other "flags" to be considered. Some have been excluded from the allowable cut; others require special management prescription based on the EPA label.

---

[1]succession as an addition into the biogeoclimatic system is presently the topic of a problem analysis being prepared by E. Hamilton, Research Branch, B.C. Ministry of Forests, 1450 Government Street, Victoria, B.C.

The forest cover inventory maps have been widely utilized for tree distributional information. For those trees considered to form climatic climaxes, the maps often provide detailed distributional data for mapping purposes in both seral and climax (mature) stands. The biophysical vegetation program has made widespread use of these maps.

Advantages of the forest cover inventory system as a habitat classification are:

1) province-wide maps available at operational scales;
2) age designations provide data for time since disturbance; disturbance type is often identified;
3) typing is done using the dominant layer of vegetation; structure may be implied from age, height, species, and stocking;
4) mapping is ongoing, with frequent updating of areas of disturbance;
5) mapping is supported by a computer based plot inventory data system that includes additional information; and,
6) the system is utilized by both forestry and range personnel; there would be a direct connection of stand type to wildlife habitat so it would be easier to consider wildlife directly in the inventory system.

Disadvantages of the forest cover inventory system as a habitat classification are:

1) lack of any ecological or climatic information to give reasonable assurance of ecological similarity of similarily labelled map units; there appears to be little internal coordination of effort between regional ecological classification programs and forest inventory to resolve the problem[1]; and,
2) type designations for nonforested types are too general and weakly defined.

6.8.2.5 Recommendations for Habitat Classification System

A combination of technical and political characteristics makes the choice of an appropriate ecological classification to be used for the habitat classification difficult. Each of the three described systems - biophysical, biogeoclimatic, and forest cover - could contribute positively to the habitat classification; each one has some disadvantages. The biophysical approach best

---

[1]There are two known projects that are attempting to resolve some of this problem (D. Meidinger, pers. comm.)

compares to the mapped habitat systems presently being utilized in the United States; its major assets are its mappability and inclusion of successional stages. The biogeoclimatic approach is roughly equivalent in the higher classes to the biophysical approach, in that units mapped are very similar. The ecosystem association system is better suited for on-site identification, especially when vegetation is in a suitable successional state, because it classifies in greater detail than the biophysical approach. Whether this detail is appropriate for the general species-habitat model is questionable; it should however, be of greater use for featured species models. Forest cover is the lone approach with total provincial coverage. If used in combination with the other approaches, an ecological framework would be introduced.

The criteria and proposed benefits have been listed; these will be used as guidelines for making decisions on options. The habitat classes will be constantly determined for British Columbia. As much as possible, the habitat classification will attempt to use existing inventory and classifications. It would appear to be easier to "correct" the deficiencies of the forest cover maps by adding ecological information than to correct the stated disadvantages of the other two systems. A proposal for a habitat classification will be expanded within the working plan, based on stated criteria. It is critical that an easy way be provided for "crosswalking" the habitat units with the ecosystems utilized by the Forest Service. Because of extensive utilization of this system by forest managers, this link will lead to easier understanding of wildlife habitats without a need for the difficult process of learning a "new classification" (B. Nyberg, pers. comm.).

The habitat classification needs to contain two subdivisions within each habitat class: a subdivision of successional and/or structural stages and a subdivision of dominant canopy closure. These factors will ensure that habitat data necessary for evaluation of the animal needs of the habitat class will be available. Discussions of and recommendations for these two subdivision categories follow, based on an understanding of how the attributes are relevant to providing life requisite needs for wildlife species (see Section 6.8.1).

6.8.2.6 Successional Stages

For any ecological classification system that deals with classes of potential vegetation (e.g. habitat class), each vegetation class can be subdivided into a number of interpretive subclasses or stages based on

changes that occur through secondary succession[1]. These stages may be arbitrary divisions of equal length (e.g. 0-10 years since vegetation removal; 10-20 years ...; 20-30 years, etc.) or may be ecologically meaningful divisions based on changes that occur through succession (e.g. structural classes: herb, shrub, young trees, mature trees).

This latter choice would be a natural interpretive classification. Succession has been described as proceeding through a number of more or less distinct stages termed seral stages until interspecific and inter-individual interactions stabilize (Walmsley et al. 1980). Whittaker has characterized succession by developmental trends that change through succession, such as nutrient stock, biomass, productivity, and species diversity (Cattelino et al. 1979). Successional models are considered to be complex, requiring a lot of research to reliably define alternative successional pathways affected by the nature and intensity of disturbances; many communities "follow a single regeneration pathway under 'normal' fire periodicities, yet widely depart from it when subjected to very short or very long inter-fire periods" (Cattelino et al. 1979). Figure 28 illustrates two hypothetical models of forest secondary succession, one that passes through two generations of trees to reach a climax stage and one that passes through a single generation. Successional stages are defined on the basis of how the tree species are interacting among themselves and with the site, shade tolerance, equilibrium of energy flows, and structure.

From a wildlife viewpoint, one criticism of the successional stages illustrated in Figure 28 is the lack of division of early seral stages where rapid structural change may occur. Figure 29, extracted from Thomas et al. (1979c), illustrates six successional stages, where the initial (and young and pioneer seral) stages (Figure 30) are divided into four structural stages: grass/forb, shrub/seedling, pole-sapling, and young. The age classes of these seres will differ between climatic areas. Thomas et al. (1979c) has joined the overmature seral and climax stands into a single class, old growth, because structurally the stands are closely related. This successional system has been applied to all wildlife habitats (plant communities); however, some plant communities do not succeed to the entire sequence of structural stages (e.g. sagebrush-bitterbrush has just two successional stages under the Thomas system). Essentially, Thomas et al. (1979c) have split forested successional

---

[1]Succession is defined by Tansley as "the gradual change which occurs in the vegetation of a given area of the earth's surface, on which one population succeeds the other" (Walmsley et al. 1980).

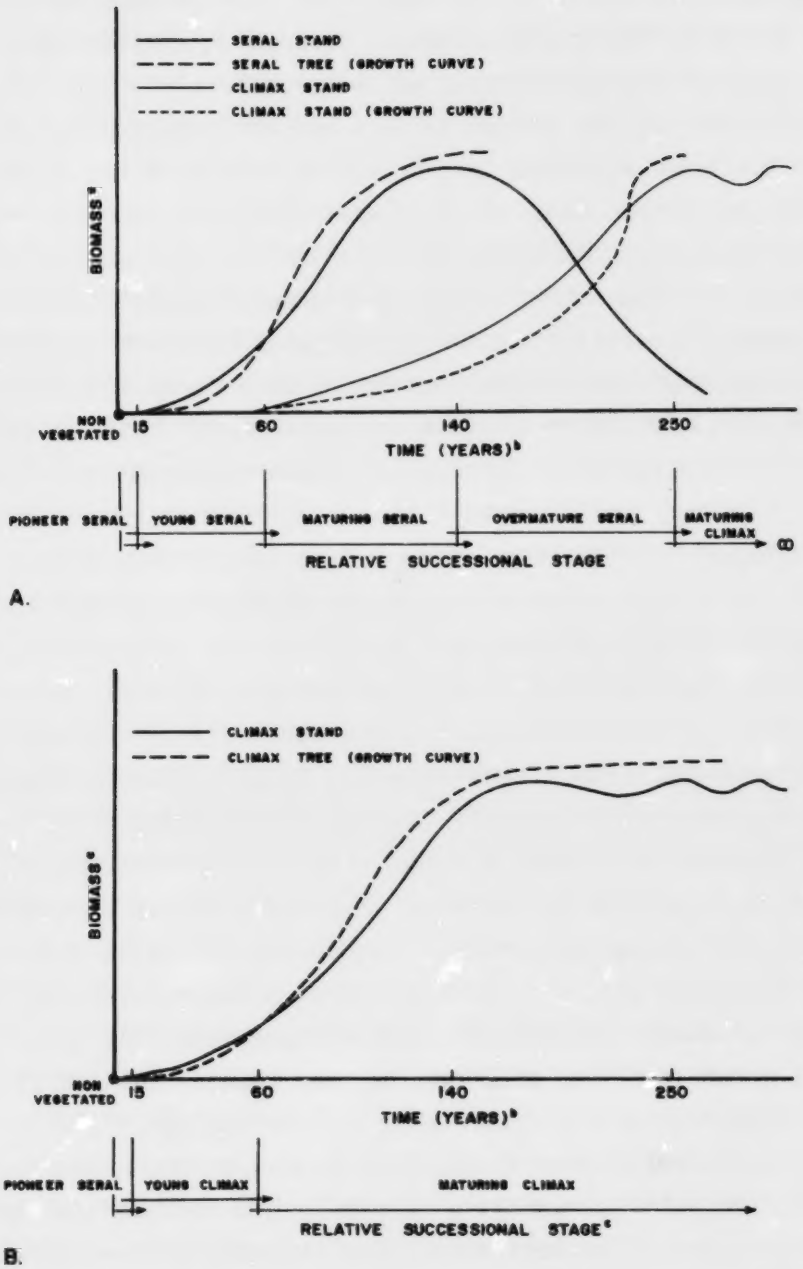


Figure 28. Hypothetical models depicting secondary succession. A. forest stand with seral tree species in successional stands. B. forest stand with climax tree species in successional stands (after Walmsley et al. 1980).

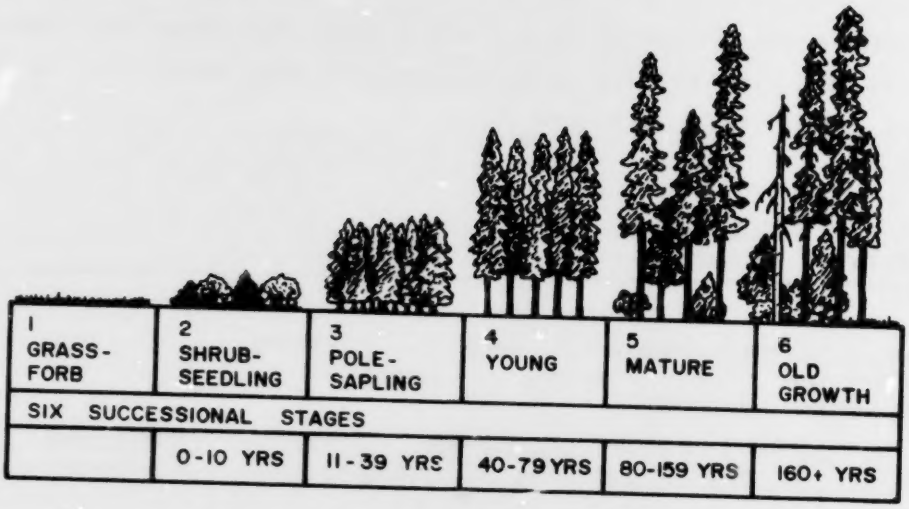


Figure 29. Successional stages for forested communities (after Thomas et al. 1979c).

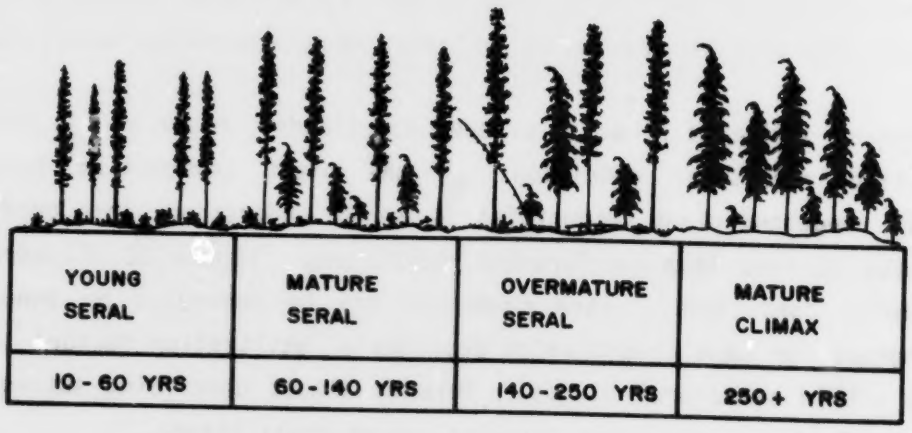


Figure 30. Successional stages for forested communities when climax trees are in successional stages (modified from Walmsley et al. 1980).

sequences similar to the one illustrated in Figure 28A and considered them as two separate plant communities. The later successional stages are included with those from successional sequences similar to Figure 28B. For example, the lodgepole pine community is described only to the young forest stage (≤79 years old): the mature and old growth stages are treated with which ever community the climax is going to be, for example subalpine fir, white fir, or mixed conifer plant communities (see Figure 31).

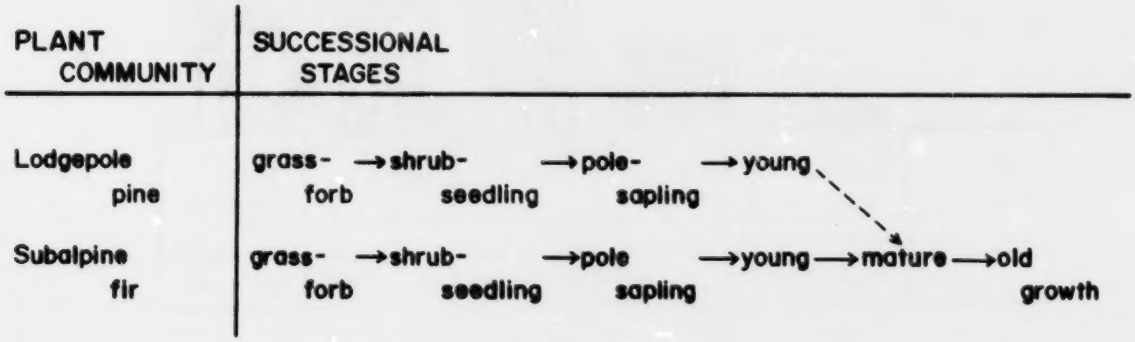


Figure 31. Overlap of secondary successional sequences between different plant communities (after Thomas et al. 1979e).

Thomas et al. (1979e) have emphasized structure, and have equated their successional stages to stand conditions in managed forest systems in order for the forest manager to "translate standard forest inventories into information on wildlife habitats". Managed stands of timber will have their structure carefully manipulated in the future; the actual successional events will be shortened with the possible exclusion of very young and older successional stages.

On nonforest dominated areas (e.g. open rangelands), Maser et al. (1982) have emphasized structural conditions of the plant communities because succession in rangeland plant communities is poorly understood, less predictable, and less obvious than in forested conditions. Figure 32 illustrates these structural conditions; each condition may be dominated by annuals, native bunchgrass, or bare ground which provides a "utilization factor" to be incorporated within structural stages. This is almost describing succession within structural classes which may parallel successional stages.

Arno (1982) has developed a means of incorporating both the taxonomic classes (successional community types) of the habitat type classification and the structural (developmental) stages. An example is shown in Figure 33.

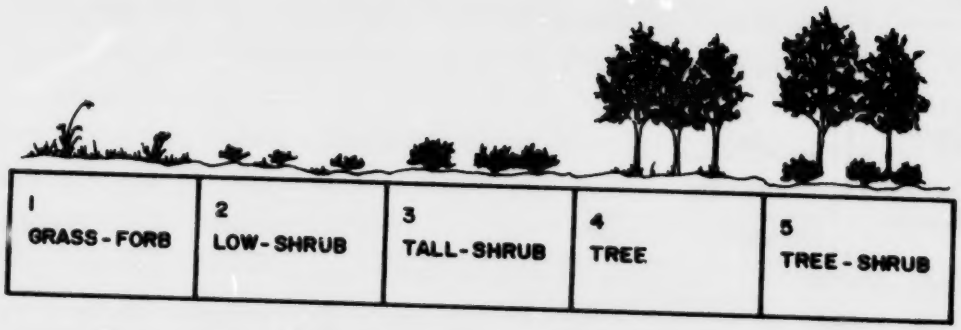
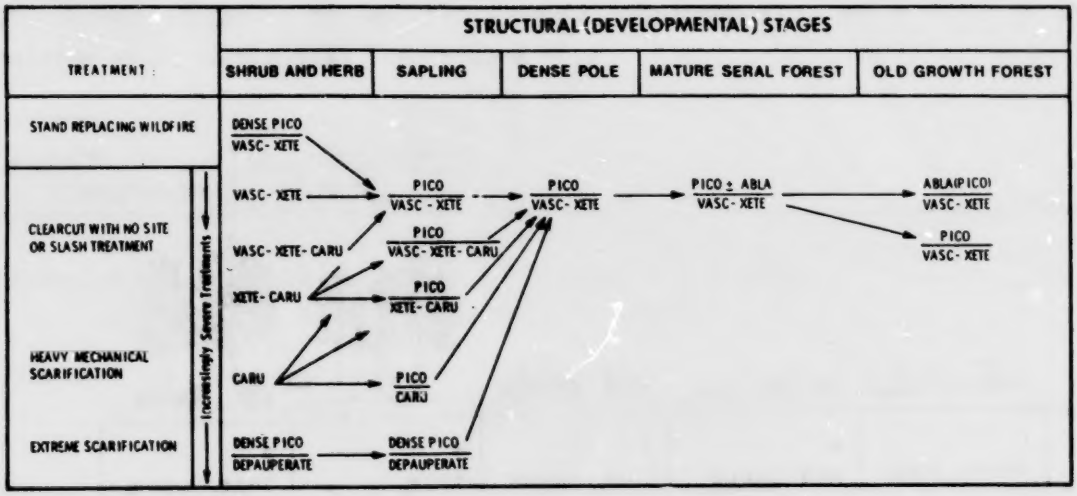


Figure 32. Structural conditions for rangeland plant communities (modified from Maser et al. 1982).

A.



B.

TREE CANOPY COVERAGE (PCT)	0–10	10–50	55–90	35–65	40–80
DOMINANT TREE D.B.H. (IN)	0–2	2–4	5–10	10–15	12–14
STAND AGE (YR)	5–22	10–45	40–120	120–200	200–300

TREES:
ABLA - Abies lasiocarpa
PICO - Pinus contorta

UNDERGROWTH:
CARU - Calamagrostis rubescens (alternate indicator for CARU is Carex geyeri)
VASC - Vaccinium scoparium
XETE - Xerophyllum tenax

Figure 33. Successional community types related to structural stages for a habitat type, with additional data onsite treatment and tree mensuration data. This example is from the Abies lasiocarpa/Xerophyllum tenax habitat type, Vaccinium scoparium phase, in western Montana (from Arno 1982:60).

Within a single figure, different successional vegetation types are related to structural stages; alternate pathways are related to treatment or kind of disturbance. Additional tree mensuration data are given for each structural stage: ranges of tree canopy closure, dominant tree diameters, and stand age. This approach could almost be considered hierarchical from a successional viewpoint: the basic change in structural stages through succession or detailed floristic data for each change in structural stage.

6.8.2.7 Recommendations for Successional Stages

It is recommended that the successional stage of forested communities[1] be divided into the stages described in the field ecosystem manual (Walmsley et al. 1980) with the following two exceptions:

1) the pioneer seral and young seral stages be divided instead into four seral stages, strongly reflecting structure: grass/forb, shrub/seedling, pole-sapling, and young seral, with definitions closely following those of Thomas et al. (1979c) and illustrated in Figure 29. Actual age designations will vary among habitat classes.

2) overmature seral be joined with mature climax (old growth) because of similarities in structure of tree canopies.

It is recommended that the successional or structural stages of shrub-dominated communities be divided into four stages: grass/forb, low shrubs, high shrubs, and shrub/tree. Shrub-dominated communities will be defined as having less than 10% tree cover and greater than 10% shrub cover potential; low shrubs belong to the B2 plant layer (<2 m high) and tall shrubs belong to the B1 layer (2-10 m high), both as defined by Walmsley et al. (1980). Seedling trees within the two shrub classes will be included in the height designations; the imminent tree canopy closure must remain at less than 10 percent.

It is recommended that the structural stages of herbaceous-dominated communities be considered in a single grass/forb class. In drier areas, where utilization from grazing may lead to some identifiable trends from annual plants to perennial grasses, a separation similar to that used by Maser et al. (1982) may be contemplated.

If for each habitat class, vegetation and vegetation succession is described for each successional stage in a similar manner to Arno (1982) (see

---

[1] Forested communities will be defined as having a tree canopy in excess of 10% or having young tree density indicating imminent tree canopy closure in excess of 10%)

Figure 33), then it will be possible to easily link alternative successional pathways to the type of disturbance. One has the option of modeling succession simply as a change from one structural class to the next or modeling taxonomic classes (eg. vegetation types; ecosystem associations) through a number of alternative pathways. For the majority of vertebrate species, the former option is probably adequate. For some featured species, the latter option may be more suitable -- it would resolve such problems as described by Stevenson (1982), who described an example of two different grass-forb communities on recently logged land on Vancouver Island. If the level of knowledge was inadequate, as on nonforested range communities (as suggested by Maser et al. 1982), then the detail of taxonomic classes could be simplified.

6.8.2.8 Canopy Closure

Canopy closure[1] is a second interpretive classification needed to evaluate wildlife habitat. If understory forage is related to canopy coverage, then an attempt to correlate canopy closure with threshold values of photosynthetic activity is necessary: when does closure or reduction of sunlight affect this activity? This suggests classes of closure would be equal in range. Bunnell and Eastman (1976:23) expected the reduction in crown closure "necessary to stimulate significant understory production to differ markedly between forest types". However, no justifications are given for any of the canopy closure class designations used in the United States handbooks (Table 6). Obviously, there is some intended link based on biological needs of either the animal or the plants comprising the habitat (Flolliot and Clary 1982). Thomas et al. (1979b) describes three canopy closure classes for effectiveness of thermal cover for elk and deer; 0-40% (submarginal), 40-70% (marginal), and 70-100% (satisfactory). Optimum canopy closure for black tailed deer in higher coastal forests for the provision of both shelter from snow and food is 60-65% (Bunnell and Eastman 1976). The biophysical vegetation program has used three classes as descriptors of forested physiognomic classes: 1-25% (parkland forest), 25-50% (open forest), and 50-100% dense forest). No justification is stated for these classes. In the California WFHR products and standards guide (Salwasser and Laudenslayer 1982), different class boundaries are given for tree/shrub stands and herbaceous stands. In the latter class, total canopy must exceed

---

[1]Same as canopy closure, crown closure, crown canopy, or canopy cover -the proportion of ground surface covered by the tree or shrub crowns as vertically projected, like a shadow.)

10% (or present young shrubs density must indicate imminent shrub or tree dominance). Canopy closure is not evaluated for seedling tree or shrub successional stages (equivalent to grass/forb and shrub/seedling successional stages of Thomas et al. [1979e]).

Dodd et al. (1972) used cover values taken from aerial photographs as a means of estimating forage production; highly significant correlations were shown for total herbage production and crown cover. This implied a linear relationship between production and crown cover. Dodd et al. (1972) recommended four broad classes of crown cover as useful in wildlife and wildlife-cattle management on forested rangelands: open, 1-20%; sparse, 20-35%; moderate, 35-55%; and dense, 55+%. Anderson et al. (1969) also found a linear correlation between percent open canopy and understory cover; they also considered the effect of canopy closure on throughfall precipitation. Jameson (1967) found that the relationship between understory biomass and crown closure follows a negative exponential relationship (Figure 34), and that a relatively large reduction in crown closure is necessary to obtain a significant response in understory vegetation. This suggests classes of canopy closure should be unequal in range. Young et al. (1967) studied the relationships of overstory cover to both percent shrub cover (Figure 35) and herbage yield and cover; there was a highly significant negative relationship between herbage yield and cover with data being recorded in three overstory cover classes: 1) open, 0-20% cover; 2) moderate shade, 21-40% cover; and 3) heavy shade, 40-100% cover.

Krueger (1980) found that studies of herbage production and canopy closure suggest four relationships (Figure 36), depending upon forest type. He concluded that "the most important feature of overstory/understory relation is that there is no set response to all conditions". He suggested that if excessive litter was not present, most situations should fit one of the patterns (Figure 36); identifying the pattern should result in management responses becoming "more predictable" and basic ecological responses can be separated from grazing responses.

Forest cover maps, presently being converted onto computer-assisted mapping systems, now have a polygon designation for crown closure, using estimates to the nearest 10%. Table 13 illustrates the codes and intervals for crown closure percent. These crown closure estimates will be eventually mapped for the entire province.

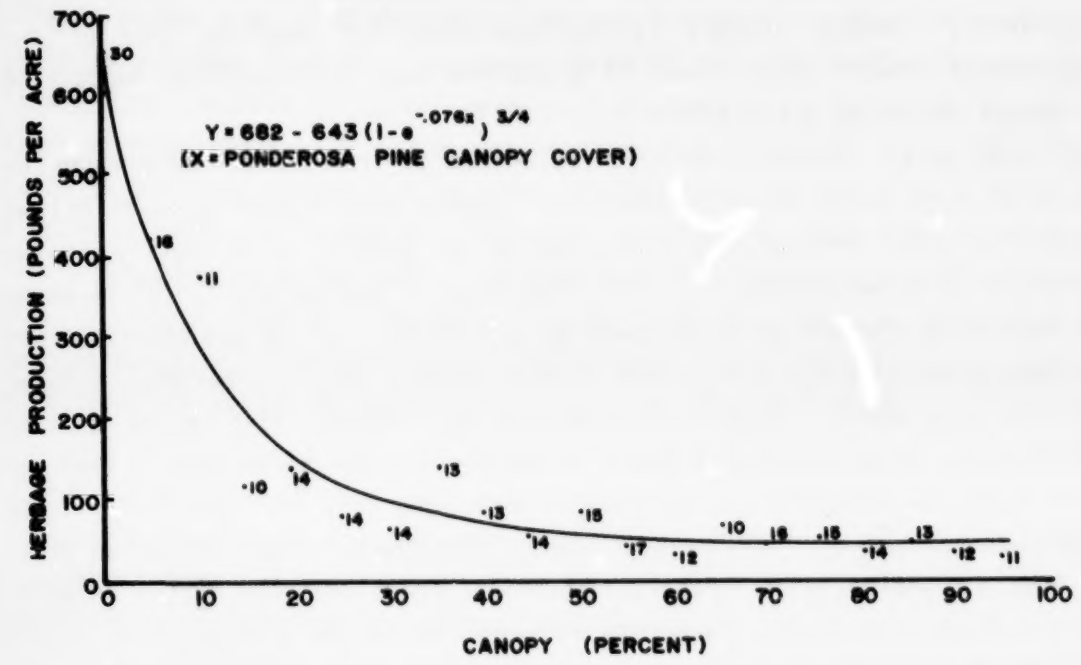


Figure 34. Relationship of herbage production (Y) to percent tree canopy (X). Numbers near the data points refer to the number of plots for the class (n=256). Data were from a ponderosa pine forest in Arizona (from Jameson 1967).

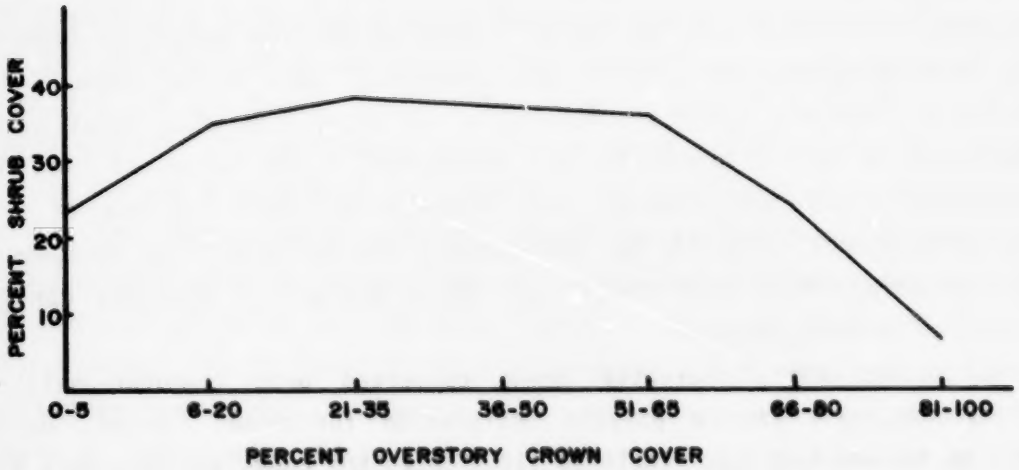


Figure 35. Relationship of shrub cover to overstory crown cover in mixed coniferous forest in Oregon (Young et al. 1967).

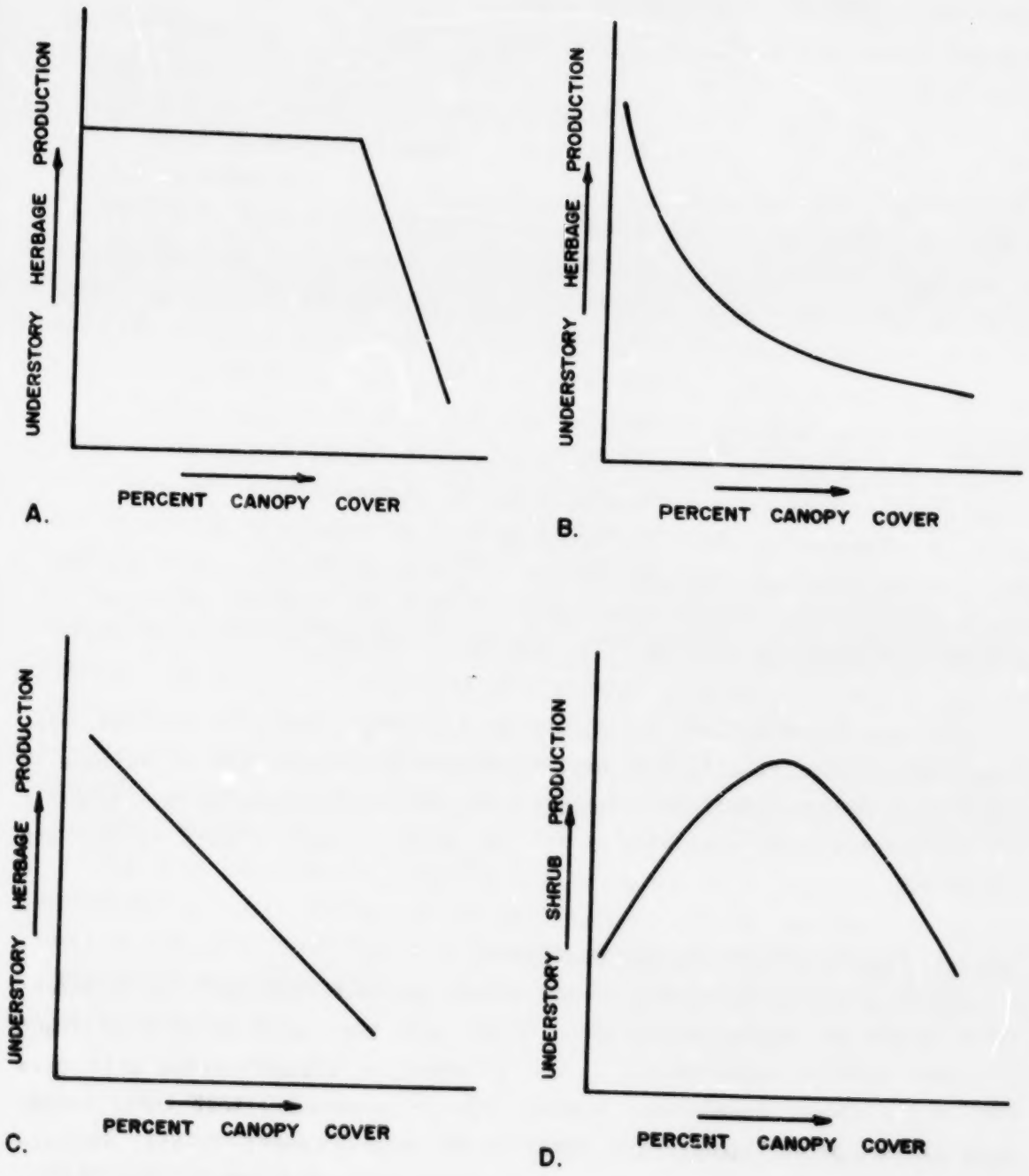


Figure 36. Relationships of herbage and shrub production to increasing levels of tree canopy cover. A. Theoretical response if light is limiting production. B. Negative curvilinear. C. Negative straight line. D. Positive curvilinear (from Krueger 1980).

Table 13. Intervals and codes for crown closure percent intervals (McLellan 1982)

Crown Closure Interval (%)	Code
0- 5	0
6- 15	1
16- 25	2
26- 35	3
36- 45	4
46- 55	5
56- 65	6
66- 75	7
76- 85	8
86- 95	9
96-100(+)[a]	10

[a] over-dense stands

It can be seen that understory/overstory relationships are variable, though the common trend is for reducing understory biomass with an increase in overstory. Nyberg (1982) has proposed more intensive studies of this response for Vancouver Island, specifically for intensive forestry effects on deer and elk forage.

6.8.2.9 Recommendations for Canopy Closure

Canopy closure shows some direct though variable relationships to understory forage and browse production; it has also been shown to be significant for some shelter requirements. Any interpretive classification will have arbitrarily chosen boundaries; however, it is recommended that three canopy cover classes be utilized at this time: 0-25%, sparse cover; 26-65%, moderate cover; 60-100%, dense cover. These categories correspond with classes mapped by the B.C. Forest Service (see Table 13). The canopy cover classes will be applied to all successional or structural stages in all habitat classes. Individual models of biomass volume/canopy relationships may be developed for each habitat class at a later time as more data become available (e.g. Nyberg 1982).

Influence of canopy closure on forage production for wildlife is under active investigation in British Columbia (Nyberg 1982). More detailed problem analyses and field investigation may result in some revisions to the above recommendations.

6.8.3 Specific Habitat Elements

6.8.3.1 Discussion

Specific habitat elements are considered to be important to include in species-habitat relationship models when they have a major impact on the usefulness of a particular habitat classification unit. Two criteria for the selection of specific habitat elements are:

1) they must be used by wildlife to support some life function; and,
2) they need to be present (either essential or preferred) in order for the capability of the habitat classification unit to be achieved.

There are a wide variety of specific habitat elements that could modify the capability of a habitat class to support a wildlife species, but are not specific within the habitat classification (i.e. not components or attributes of the chosen system). These elements are often more related to specific site history than to the habitat class per se; the habitat class may have the inherent capability of providing the element without it being a constant attribute of the class. Some of these elements are not measurable except by on-site examination; others are interpreted if the habitats are ecologically described using a range of natural integrated site factors, such as soils, landforms, vegetation, and climate.

The list of potential elements may be quite short and general, roughly equivalent to Thomas' (1979c) unique and special habitats (see Table 8) or very specific and detailed. The list of habitat elements may vary among handbook areas (e.g. characteristics of marine shorelines would not be applicable in interior areas).

6.8.3.2 Recommendations

It is recommended that specific habitat elements be included in the basic species-habitat model as additional attributes to those included in the habitat classification. Table 14 lists a preliminary selection of specific habitat elements. This list will have to be refined to fit characteristics of British Columbia wildlife and habitat in the working plan (in prep.).

Table 14. Proposed specific habitat elements for British Columbia habitat handbooks (preliminary). Wildlife use and often depend upon specific habitat elements which are not implied by the Habitat class. Examples are snags for nesting, shrub understory layer for hiding, and fungi for feeding. Specific Habitat Elements are differentiated according to those consumed as diet items, and those used as a "substrate" for feeding (but not as a diet item), reproduction, or cover (Salwasser and Laudenslayer 1982)

1. Vegetative Diet Elements

Specific Habitat Element	
Lower Plants	
Fungi	Saprophytic spore-forming, non-vascular plants such as mushrooms, molds, etc.
Lichens	Algal-fungal symbiotic associations on solid surfaces.
Moss	Bryophytic plants.
Ferns	Spore-forming vascular plants with leaf-like fronds.
Kelp	Large, coarse, brown algae.
Algae	Any algae other than kelp.
Higher Plants (excludes seeds)	
Graminoids	Grases and grass-like plants.
Forbs	Herbaceous dicotyledonous plants.
Shrubs	Woody plants of smaller stature than trees when fully grown.
Tree leaves	The leaves (and/or new stem production) of trees.
Sap	The fluid part of a plant.
Roots	The underground parts of plants.
Fruits	
Seeds	The ripened ovules of flowering plants; in this case, exclusive of the seeds listed below.
Grain	A single, hard seed of a cereal grass.
Berries	Pulpy fruit of relatively small size.
Fruits	Pulpy succulent reproductive body of a seed plant.
Nuts	Hard-shelled, dry fruit.
Cones	Ovule-bearing mass of scales or bracts in gymosperm trees.
Flowers	Flowers
Nectar	The sweet fluids secreted by flowers.

2. Animal Diet Elements

Specific Habitat Elements	
Invertebrates	
Invertebrates	Animals without backbones; in this case, a more general term than the three immediately below.
Terrestrial insects	Insects fed upon while not on or under water or in the air.
Flying insects	Insects fed upon in the air.
Aquatic invertebrates	Invertebrates fed upon on or below the water surface.
Vertebrates	
Fish	Fish.
Amphibians	Amphibians.
Reptiles	Reptiles.
Small birds	Birds that weigh <4 oz.
Medium birds	Birds that weigh 4 oz. to 1 lb.
Large birds	Birds that weigh >1 lb.
Small mammals	Mammals that weigh <4 oz.
Medium mammals	Mammals that weigh 4 oz. to 5 lbs.
Large mammals	Mammals that weigh >5 lbs.
Carrion	Any dead animal matter, first encountered while dead.
Eggs	Any eggs of birds or reptiles.

3. Live Vegetation Elements

Tree layer	Subcanopy trees >10% cover.
Shrub layer	Subcanopy shrubs >10% cover.
Herbaceous layer	Subcanopy herbaceous >10% cover.
Hardwood trees	Hardwood trees with dbh >11" (small tree or larger).
Pine trees	Trees of the genus *Pinus* with dbh >11" (small tree or larger).
Fir trees	Trees of the genus *Abies* with dbh >11" (small tree or larger).
Broken top live tree	Trees with dbh >11" which have a broken top.

Specific Habitat Element	
Trees with loose bark	Trees possessing loose bark.
Trees with cavities	Trees possessing one or more cavities.
Riparian inclusion	Small (not mapable) stand of vegetation which is associated with permanent water, includes seeps.
Submerged aquatics	Rooted vascular plants which do not emerge above the water surface.
Emergent aquatics	Rooted vascular plants which emerge above the water surface.

4. Dead or Decadent Vegetation Elements

a. Snags

Snags are standing dead or mostly dead trees.

Snag Size Class	dbh Standard
Small snag	<15"
Medium snag	15"-30"
Large snag	>30"
Stump	any snag <10' tall

Snag Decay Class	
Sound snag	Top intact, bark on, wood sound.
Rotten snag	Top broken, bark sloughing off, or wood decaying and falling apart.

b. Vegetation Residues

Residues is all dead and decaying vegetation, from duff to downed logs lying on the ground.

Residue Size Class	Diameter Standard
Duff	Non-structured decaying matter.
Litter	<1.0"
Small slash	1-3"
Large slash	3-10"
Medium log	10-20"
Large log	>20"
Brush pile	

Decay classes apply to size classes 4, 5, and 6 only.

Log Decay Class	
Sound log	Wood sound.
Rotten log	Wood rotting, falling apart.
Hollow log	Center of log is hollow.

5. Habitat Edge Elements

Edges are areas of transition between different Habitats. Only those edges which constitute a major habitat change are considered important. Edge classes are:

Edge Class	
Tree/Shrub	Transition between any stand of trees size class 3, 4, 5 or 6, and classes 2, 3 or 4.
Tree/Grass	Transition between any stand of trees size class 3, 4, 5 or 6, and tree size class 1, or shrub class 1, or any herbaceous stand.
Tree/Water	Transition between any stand of trees size class 3, 4, 5 or 6, and any wetland or aquatic type.
Tree/Agriculture	Transition between any wildland tree stand of size class 3, 4, 5 or 6, and any agricultural cover type.
Shrub/Grass	Transition between any stand of shrubs class 2 or any stand of shrubs classes 2, 3 or 4, and any herbaceous stand, or any stand of trees or shrubs class 1.
Shrub/Water	Transition between any stand of shrubs classes 2, 3, or 4, and any wetland or aquatic type.
Shrub/Agricultural	Transition between any wildland stand of shrubs of size class 2, 3, or 4, and any agricultural cover type.
Grass/Water	Transition between any herbaceous stand, or any stand of shrubs or trees size class 1, and any wetland or aquatic type.
Grass/Agricultural	Transition between any wildland herbaceous cover type or any tree or shrub stand of size class 1, and any agricultural cover type.
Water/Agricultural	Transition between any wetland or aquatic type and any agricultural cover type.

6. Physical Elements

Physical elements are edaphic or topographic features within Habitats.

a. Soil Elements

Soil Class	
Friable soil	Easily crumbled or pulverized soil.
Organic soil	Soil which contains a high percentage (>20%) of organic matter.

Soil Class	
Gravelly soil	Soil dominated by gravel size grains (2 to 75 mm diameter).
Sandy soil	Soil dominated by sand size grains (0.05 to 2 mm diameter).
Aerated soil	Soil that is well drained and aerated.
Saline soil	Soils which are saline or alkaline, supporting vegetation which is salt tolerant (e.g. pickleweed, salt grass, shadscale, iodine bush).

b. Geologic Elements

Geologic Formation Class	
Barren	Areas within a vegetation dominated Habitat that are devoid of vegetation.
Bank	The rising ground bordering a body of water or forming the edge of a cut or hollow.
Sand dune	A hill or ridge of sand piled up by the wind.
Burrow	A hole or excavation in the ground made by an animal.
Cave	A natural underground chamber open to the surface.
Cliff	A steep, vertical, or overhanging face of rock or earth.
Lithic	A scatter of rocks <10" diameter on the ground.
Rock	An outcrop of rocks >10" diameter.
Talus	A slope formed by an accumulation of rock debris, often at the base of a cliff.
Steep Slope	Slopes >50 percent.

7. Aquatic Elements

Aquatic elements are natural or artificial sources of free water and associated vegetation.

Aquatic Element	
Water	Any source of free water.
Vernal pools	Pools, ponds, or lakes that retain water during spring but dry up in summer.
Ponds	Permanent water bodies of <5 surface acres.
Lakes	Permanent lakes or reservoirs of >5 surface acres.
Intermittent streams	Intermittent lotic water courses, e.g. go dry during part of year.
Permanent streams	Permanent lotic water courses >20 feet wide during dry season.
Rivers	Permanent lotic water courses >20 feet wide during dry season.
Mud flats	Expanses of mud along water body.
Springs	Freshwater springs or seeps.
Mineral springs	Mineral springs or seeps.
Bogs	Bogs or fens.
Hot springs	Hot water springs.
Tidepools	Pools formed in potholes during th ebbing of a tide.
Slow water	Streams with low gradients and low water velocity (<0.15 m/sec [0.5 ft/sec]) with bottoms that are at least partially silted.
Fast water	Streams with high gradients and high water velocities (>0.60m/sec [2 ft/sec]) with unsilted bottoms.

8. Man-made Elements

Man-made elements are artificial structures.

Man-made Element	
Nest island	An island constructed for bird nesting.
Nest box	A box that provides secondary cavity nesters a nesting site.
Nest platform	A platform constructed for large bird nests.
Transmission lines	Aboveground transmission lines (e.g. electricity, telephone) and their support towers.
Buildings	Houses, sheds, etc.
Fences	Any type of fence.
Campgrounds	Physical structures of campgrounds along with associated human use (refuse, food scraps, etc.).
Pack stations	Pack stations along with associated human use.
Water	Any artificial water catchment, storage, and distributing structure, e.g. pit, guzzler, well, etc.
Dump	Sanitary landfills.
Wharf	Principally wooden structures extending into aquatic habitats.
Jetty	Rock or concrete structures extending into aquatic habitats.
Salt ponds	Saline ponds used for salt extraction.

6.8.4 Life Requisites

6.8.4.1 Discussion

Wildlife may use different habitats or different parts of a habitat for various functions, such as feeding, reproduction, shelter, or escape. These functions, called life requisites, are equivalent to life history categories (Salwasser and Laudenslayer 1982) or habitat components (Coulombe 1978). This distinction is important in evaluating or rating species-habitat relationships, because the ability to evaluate a habitat class improves with a separation of species biology into life requisite classes. Management can then be directed towards providing the right "mix" of habitat units to provide for the full range of necessary life functions of a species.

One important determinant of life requisites classes is that:

1) they should reflect a direct contribution to either survival or reproduction of the species.

Coulombe (1978) classified habitat components into water, food, cover, reproduction, and special needs, defined as classes of components within the total living space of an animal population "that, when summed, equal the external" life requirements of a species. These components are similar to those proposed by Bunnell and Eastman (1976). Water can be considered as part of the food resource. Salwasser and Laudenslayer (1982) define the cover class as including all nonfeeding and nonreproductive activities, such as resting, thermal protection, escape, hiding, transit, and security. Stevenson (1982) uses various data elements of habitat for deer and elk to provide interpretations for food availability, shelter cover, hiding and escape cover, reproductive cover, local climate, ease of movement, and spatial distributions of habitat components; these are similar to those proposed by Harcombe (1981b). Because of the climatic extremes of temperature and precipitation in British Columbia, cover from these extremes is often important for wildlife survival. As well, other forms of cover have a strong influence on habitat capability, especially escape terrain for larger ungulates such as white-tailed deer, mountain goat, and bighorn sheep.

6.8.4.2 Recommendation

It is recommended that three life requisites should be rated for each species for each level of the habitat classification (habitat class, successional stage, canopy closure class). The three areas of activity to be rated will be reproduction, feeding, and special needs. Special needs will

include all activities not directly related to feeding or reproduction, dependent upon animal species. These special needs may be considered as a set of separate additional categories, such as climatic shelter and antipredator cover.

6.8.5 Capability Coefficients

6.8.5.1 Discussion

Species relate to habitat attributes through their life requisites of reproduction, feeding, and special needs. The actual relationships part of the species-habitat matrices is indicated by some relative scale or index of capability of the attribute to support the wildlife activity. Salwasser and Laudenslayer (1982) also rate each specific habitat element on the assumption that the presence or absence of that element modifies the capability of a habitat to support the species.

The type of habitat value ratings or coefficients required should be selected using two criteria:

1) a proportional or ordination scale is preferrable to a presence/absence scale because it contains a greater amount of information and the divisions are more equitable to each other; and,
2) coefficients should be defined in terms that could be measured.

The B.C. Ministry of Environment uses a six-class scale to express the ability of the land to support ungulates: very high (class 1); high (class 2); moderate (class 3); low (class 4); very low (class 5); and no capability (class 6) (Demarchi et al. 1983). Class 1, very high, is defined for each ungulate species by potential carrying capacity estimates, measured in animals/square kilometer/year. These vary among species (Table 15). Other classes are expressed as percentages of the class 1 values: class 2 = 51-75% of class 1 capability; class 3 = 26-50% of class 1 capability; class 4 = 6-25% of class 1 capability; class 5 = <5% of class 1 capability. Animal ranges that are not used year-round must support proportionally higher animal numbers to achieve the same capability coefficient as year-round ranges.

For the basic species-habitat matrices, (where each life requisite of every vertebrate species is rated for each habitat class), a six-part scale would be too complex for most species because of poor knowledge of some species' biology. It does have the advantage, however, of being quantifiable. In the habitat programs in the United States, a number of capability coefficients have been utilized (see Section 4.6.5). Some of these do not

Table 15. Potential carrying capacity estimates (animals/square kilometer/year) for ungulate capability class rating (from Demarchi et al. 1983)

Classes[a]	Capability	Black-tailed Deer	Mule Deer White-tailed Deer	Mountain Sheep	Elk	Caribou	Mountain Goat	Moose
1C		33.9-40.5	26.4-31.5	20.1-24.0	1.64-19.5	12.6-15.0	8.8-10.5	7.6-9.0
1B	very high	27.1-33.8	21.1-26.3	16.1-20.0	13.1-16.3	10.1-12.5	7.1- 8.7	6.1-7.5
1A		20.4-27.0	15.9-21.0	12.1-16.0	9.9-13.0	7.6-10.0	5.3- 7.0	4.6-6.0
2	high	13.7-20.3	10.7-15.8	8.1-12.0	6.6- 9.8	5.1- 7.5	3.6- 5.2	3.1-4.5
3	moderate	6.9-13.6	5.4-10.6	4.1- 8.0	3.4- 6.5	2.6- 5.0	1.8- 3.5	1.6-3.0
4	low	1.5- 6.8	1.2- 5.3	0.9- 4.0	0.8- 3.3	0.6- 2.5	0.4- 1.7	0.4-1.5
5	very low	<1.4	<1.1	<0.8	<0.7	<0.5	<0.5	<0.3
6	none	0	0	0	0	0	0	0

[a]Ranges calculated using the maximum of Class 1A as 100%. Classes 5 to 1C respectively are: <5%; 6-25%; 26-50%; 51-75%; 76-100%; 101-125%; 126-150%. The use of decimals is to prevent rounding errors: an estimation of carrying capacity to this accuracy is not expected.

Table 16. Proposed system for rating the habitat capability of vegetation types in the California Wildlife Habitat Relationships Program (from Salwasser et al. 1980)

Relative Habitat Capability	Recruitment / Mortality		Emigration / Immigration
High	> 1	or	> 1
Moderate	1		1
Low	< 1		< 1

have measurable characteristics to define classes, though Thomas (1979c) does separate classes on percent probability of occurrence: primary (≥40% probability of occurrence) or secondary (<40% probability of occurrence). Recently, Salwasser et al. (1980) proposed a system for rating the habitat capability based on recruitment[1]/mortality and/or emmigration/immigration rates, with three classes (Table 16); however, this was not utilized in the later products/ standards publication for wildlife (Salwasser and Laudenslayer 1982), probably due to lack of available data for many species.

6.8.5.2 Recommendations

The species-habitat relationships should use a modified ungulate-capability type scale of ratings, simplified to be more applicable to the basic species models. A high rating would include class 1 and 2, a moderate rating class 3, a low rating a class 4 and 5, and a "not used" rating equivalent to class 6. The major difference would be that the ratings would not include a "time" or season definition; the habitat class would be rated solely on the ability of that class to meet the life requisite need, as implied by probability of occurrence by the species. Those life requisites rated would be reproductions feeding, and special needs, as defined in Section 6.8.4.2. An attempt will be made to include in the definition of these classes some rating of capability in relation to the role of the habitat class condition in the population dynamics. Thus, the suggested habitat ratings, with definitions, are given in Table 17.

Ratings for the impact on presence or absence of specific habitat elements (see Table 14) on the capability of that habitat to support the species should follow that described by Salwasser and Laudenslayer (1982). These, with definitions, are given in Table 18.

6.8.6 Season of Use

6.8.6.1 Discussion

Season of use data identify the time of use of the habitat class by each species. If species are to be grouped into guilds for some habitat evaluations, then season of use is a definite component of life requisite

---

[1]Recruitment is considered to be the addition of reproductive aged individuals from within the population.

Table 17. Proposed capability coefficients for basic species-habitat relationships models

Rating	Definition
High	meet the life requisite need (reproduction, feeding, or special needs) in support of a relatively high population density (as implied by probability of occurrence of greater than 50%); has potential to support positive recruitment (an increasing population or a stable population that produces a dispersal excess); unit use greater than 50% of the time
Medium	meet the life requisite need (reproduction, feeding, or special needs) in support of a relatively medium population density (as implied by probability of occurrence of 26-50%); has potential to support neutral recruitment (a stable population with no dispersal excess); unit use 26-50% of the time
Low	meet the life requisite need (reproduction, feeding, or special needs) in support of a relatively low population density (as implied by a probability of occurrence less than 25%); has potential to support negative recruitment (nonviable population, inhabitated primarily by colonizing individuals); unit use less than 25% of the time
None	does not meet life requisite needs; species is not expected to occur in the habitat

Table 18. Coefficients for rating importance of specific habitat elements (from Salwasser and Laudenslayer 1982)

Rating	Definition
Essential	The element must be present within the home range of the species if the species is to be present.
Secondary	An element which must be present within the home range of the species unless it is compensated by the presence of other secondarily essential elements.
Preferable	The element is used by the species to a greater degree than its abundance, and the presence of the element enhances habitat capability for the species, but the element is not essential for species presence.
Not Rated	The species may use the element, but the presence of the element does not enhance habitat capability for the species.

attributes. A species is considered to occupy a geographical area if it is a yearlong resident or a regular migrant, regardless of relative abundance.

In choosing meaningful subdivisions of species' annual cycles, the subdivisions should:

1) be of value for evaluating the effect of management activity on the species; and,
2) relate to the seasonal changes in species activities.

There are two primary options for subdividing the annual cycle: a four-way split of spring, summer, fall and winter (e.g. Thomas et al. 1979c) or a twelve-way split into months: January - December. The former is used more commonly in the United States programs, partly because it is often easier to distinguish and partly because it encompasses more meaningful climatic breaks that influence behavioral changes in wildlife, especially reproductive and feeding needs. The first option of seasons classes could result in a combination of thirteen possibilities (e.g. Table 19).

Most management activities are strongly influenced by climatic conditions and the relationship of plant growth to climate. Monthly variation among years is partially obscured if time is considered within seasonal classes - winter logging may be dependent upon ground freezing, though this freezing may occur in November, December, or January dependent upon the weather for that particular year. As well, there is a possibility that the definitions of the seasons may need to be modified as one moves northward, as winters become more severe and longer. This would be of special importance to the boreal area of northern British Columbia.

Areas of winter habitat are critical to many wildlife species that remain as yearlong residents in British Columbia, primarily because of severe winter climate, often resulting in deep snow. These winter conditions may vary considerably from year to year, so much so that some species may utilize two entirely different habitat combinations dependent upon whether or not snow limits food availability or animal movement (D. Low, pers. comm.). During mild winters, some species will remain distributed on spring or fall ranges, where food may be of better quality, available because of low snow, and/or where it is warm enough that shelter cover does not become a critical element of habitat. During severe winters, some species are forced by deep snow to small ranges, often radically increasing animal densities. These habitats are the traditional critical winter ranges. A division of seasonal use between mild

Table 19. Recommended season of use classes and definitions

Season of Use	Definition
1. Yearlong	Yearlong resident
2. Mild Winter	November-March only during mild winters
3. Severe Winter	November-March only during severe winters
4. Spring	March-June only (vernal)
5. Summer	June-September only
6. Fall	September-November only
7. Mild Winter-Spring	Mild Winter through Spring
8. Severe Winter-Spring	Mild Winter through Spring
9. Spring-Summer	Spring through Summer
10. Spring-Fall	Spring through Fall
11. Spring and Fall	Migratory in the Spring and Fall only
12. Summer-Fall	Summer through Fall
13. Fall-Spring	Spring
14. Summer and Winter	Summer and Winter only
15. Fall-Severe Winter	Fall through Severe Winter
16. Fall-Mild Winter	Fall through Mild Winter

and severe winters is not only applicable to ungulates but also applies to a wide spectrum of species of birds (D. Low, pers. comm.).

6.8.6.2 Recommendations

It is recommended that season of use is defined on the basis of one or more of the four seasons, as shown in Table 19. These are identical to those described by Salwasser and Laudenslayer (1982) with two exceptions - the addition of a summer and winter category to encompass the double migration of caribou (and maybe a similar response in other wildlife, such as ptarmigan) (D. Low, pers. comm.), and the division of winter into two types: mild winters and severe winters.

6.9 Detailed Species-Habitat Models

6.9.1 Introduction

More detailed information on species-habitat relationships are required for some species and special habitats, in conjunction with better detail on management alternatives. These more detailed reports have been referred to as Specific Management Documents by Salwasser et al. (1980), to be patterned after chapters 3 through 8 in Thomas et al. (1979c) but written with localized modifications.

The following two sections discuss the criteria, options, and recommendations for these two detailed levels of species-habitat information.

6.9.2 Selection of Featured Species

6.9.2.1 Discussion

Managers will never be able to monitor population trends and population viability for all vertebrate species in their management area. Managers operate with a list of species or species group priorities that best reflect the perceived needs of society. The manager must select a group of species that will act as sensors at critical spots in the planning unit if the goals of both diversity and population viability of species are to be achieved. In the United States, these selected species are called management indicator species (MIS)[1].

---

[1]Salwasser and Unkel (1981) define management indicator species as "plant or animal species whose population parameters (presence, number, density, sex ratio, age structure, recruitment rates, mortality rates, or dispersal equilibria) can be used to show the effects of land and resource management practices and actions on themselves, other species (e.g. guilds), or an ecosystem which is being treated as a management unit".

Regulations for land and resource management and planning in National Forests require that "population trends of the management indicator species will be monitored and relationships to habitat changes determined" (U.S. Department of Agriculture, Forest Service 1982a). They are selected because "their population changes are believed to indicate effects of management activities".

American regulations suggest that management indicator species should be selected from the following categories:

1) endangered and threatened plant and animal species identified for the planning area (recovery species[1]);
2) species with special habitat needs that may be influenced significantly by planned management programs (specific habitat indicators[1]);
3) species commonly hunted, fished, or trapped (featured species[1]);
4) nongame species of special interest (featured species[1]); and,
5) additional plant or animal species selected because their population changes are believed to indicate the effects of management activities on other species of selected major biological communities (ecological indicators[1]).

The categories are not considered to be mutually exclusive. Salwasser and Unkel (1981) state that by intelligent selection of the management indicator species, requirements for diversity and population viability may be partially met, and this selection "will provide an extra measure of insurance against problems arising out of intended land management".

Criteria for the selection of management indicator species are important; this selection must be related to the particular planning unit. Salwasser and Unkel (1981) list three mandatory criteria:

1) all listed threatened and endangered species;
2) all sensitive species whose populations or habitat are measurable and will be affected by anticipated vegetative manipulation; and,
3) significant harvest species and highly valued nonconsumptive species identified in planning issues.

If species selected from the above three criteria do not meet the following criteria, additional species should be selected as necessary:

---

[1]Category names given in Salwasser and Unkel (1981.

4) species with specific habitat needs that will be affected by planned management programs[1];
5) species whose populations indicate the welfare of other species that are important in forest management (e.g. using deer to represent quail, or an indicator of a guild such as snag dependent feeders);
6) species that are dependent on early successional vegetation; and,
7) species that are dependent on late successional vegetation.

Where multiple species are equally representative of the above criteria, the species that is easiest or cheapest to monitor should be chosen.

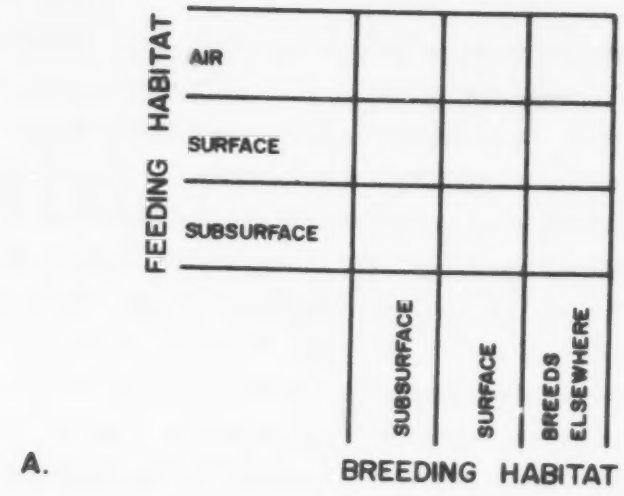
The concepts of the specific habitat indicator and ecological indicator species are difficult. One approach that aids in their selection is the formation of species groups or guilds. Root (1967:335) defines a guild as "... a group of species that exploit the same class of environmental resources in a similar way. This term groups together species, without regard to taxonomic position, that overlap significantly in their niche requirements." Two ways of guild formation are possible, using flexible rules (e.g. Short 1982; Short and Burnham 1982) or inflexible rules (e.g. Thomas et al. 1979e). This flexibility applies more to management or planning than to the concept. Thomas et al. (1979e) called guilds "life forms"; they are based on similarities of reproductive and feeding use of habitat (Figure 37). Short and Burnham (1982) used guild blocks which are derived from two resource gradients that are important to wildlife species: 1) physical positions within the structure of a vegetative community where food sources occur and 2) physical positions within the structure of a vegetative community where breeding substrates occur. The blocks for any one vegetative community can be defined by "constructing a matrix where the y-axis represents loci where food sources occur and the x-axis represents loci where breeding occurs" (Short 1982:58-59). Figure 38 illustrates matrices for upland grassland and coniferous forest habitat. The guild block concept relates the occurrence of groups of species to major structural features of the vegetative community. It has been used as a complicated model for calculating actual and potential wildlife habitat values by comparing structure of vegetation present with maximum diversity capability. However, the approach may be used simply to better define guilds. The guild selection can be tempered by the concerns of management effects on the available habitats. A major key is the interconnection of diversity

---

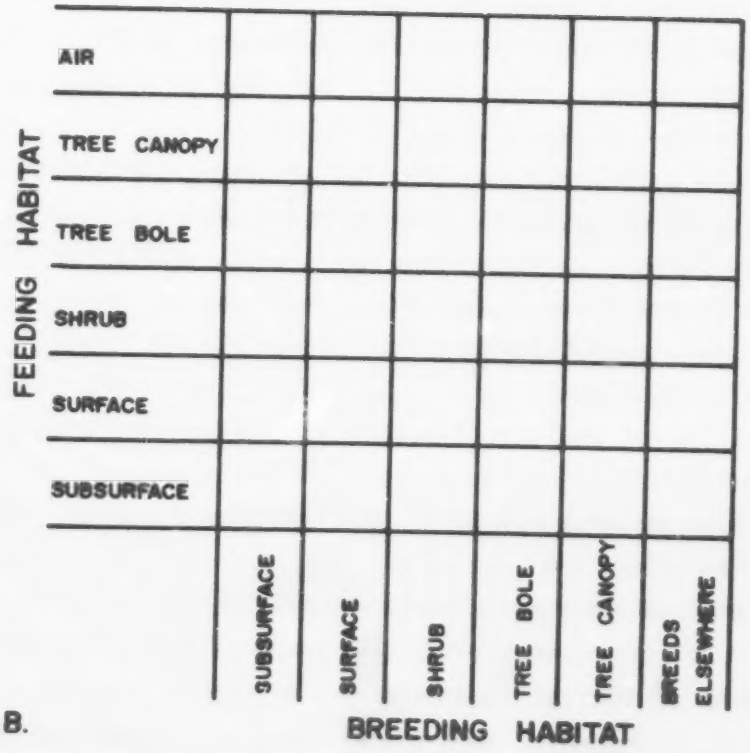
[1]To include species especially sensitive to any form of human disturbance, such as grizzly bear (B. Pendergast, pers. comm.).

Life form	Reproduces	Feeds	No. of species	Examples
1	in water	in water	1	bullfrog
2	in water	on the ground, in bushes, and/or in trees	9	long-toed salamander, western toad, Pacific treefrog
3	on the ground around water	on the ground, and in bushes, trees, and water	45	common garter snake, killdeer, western jumping mouse
4	in cliffs, caves, rimrock, and/or talus	on the ground or in the air	32	side-blotched lizard, common raven, pika
5	on the ground without specific water, cliff, rimrock, or talus association	on the ground	48	western fence lizard, dark-eyed junco, elk
6	on the ground	in bushes, trees, or the air	7	common nighthawk, Lincoln's sparrow, porcupine
7	in bushes	on the ground, in water, or the air	30	American robin, Swainson's thrush, chipping sparrow
8	in bushes	in trees, bushes, or the air	6	dusky flycatcher, yellow-breasted chat, American goldfinch
9	primarily in deciduous trees	in trees, bushes, or the air	4	cedar waxwing, northern oriole, house finch
10	primarily in conifers	in trees, bushes, or the air	14	golden-crowned kinglet, yellow-rumped warbler, red squirrel
11	in conifers or deciduous trees	in trees, in bushes, on the ground, or in the air	24	goshawk, evening grosbeak, hoary bat
12	on very thick branches	on the ground or in water	7	great blue heron, red-tailed hawk, great horned owl
13	in own hole excavated in tree	in trees, in bushes, on the ground, or in the air	13	common flicker, pileated woodpecker, red-breasted nuthatch
14	in a hole made by another species or in a natural hole	on the ground, in water, or the air	37	wood duck, American kestrel, northern flying squirrel
15	in a burrow underground	on the ground or under it	40	rubber boa, burrowing owl, Columbian ground squirrel
16	in a burrow underground	in the air or in the water	10	bank swallow, muskrat, river otter
		Total:	327	

Figure 37. Life form descriptions (from Thomas et al. 1979e)



A.



B.

Figure 38. Guild blocks for two vegetative communities A. grassland habitat B. mature coniferous forest (from Short 1982).

measurement and "similarity of use" measurements that these flexible guilds can provide.

British Columbia does not have a specific policy or regulation in place that relates to the concept of management indicator species in the U.S. National Forests, though our two wildlife management goals closely resemble the American legal mandate for diversity and population viability. The MIS approach allows for a monitoring of wildlife and habitat that could help the manager "measure" the effectiveness of attaining his wildlife goals.

6.9.2.2 Recommendation

There is a need to provide additional management related information for some wildlife species at a level higher than the basic species-habitat relationships model. Using a similar approach to the management indicator species concept in British Columbia would be a logical approach in helping managers achieve their management goals. Traditional species of importance to the wildlife manager will continue to be studied and monitored. The MIS concept ensures that all groups of wildlife receive similar consideration. It is therefore suggested that the habitat handbooks need to highlight those species that are chosen; these will be referred to as management indicator species (not in the narrower sense of Salwasser and Unkel 1981). It is recommended that a policy for the selection of management indicator species for British Columbia be implemented. Species can then be selected using the same criteria as in the United States from the same categories of choices, with a emphasis based on such items as (Salwasser and Tappeiner 1980):

1) local and regional demand;
2) legal requirements;
3) capability of available habitat (including kinds, amounts, quality, pattern);
4) logistics of being compatible and feasible with other resources in the planning area; and,
5) interest and ability of local manager.

Managing a selected number of species requires a detailed understanding of the relationship of habitat conditions to different population levels, from minimum conditions required to support viable populations to conditions required for maximum capability. Gaining this understanding will require development of such approaches as habitat capability models or habitat suitability indices (U.S. Department of the Interior, Fish and Wildlife Service 1980a; 1980b; 1981).

6.9.3 Selection of Featured Habitats

6.9.3.1 Discussion

Certain habitats or habitat elements may have a greater proportional importance to a variety of wildlife than others. These habitats may be required for a species to be present (essential) or not required but enhancing the habitat value for a species (preferrable). These habitats and their management may be addressed in greater detail to establish quality standards for the entire animal community dependent upon them (Nelson and Salwasser 1982). It is often easier to manage the habitat or specific habitat element for an entire group or guild of species. Examples of such special habitats presently discussed in United States handbooks include snags, riparian areas, meadows, cliffs, and talus slopes (see Table 8).

The main criteria for the selection of habitats or specific habitat elements for featured coverage will vary according to area. If feature habitats are of essential importance to a group of wildlife in the handbook area, then additional coverage of quality standards and enhancement opportunities is important. There should be a balance between featured habitats and featured species; choosing a habitat such as potholes and lakes precludes the need to treat ducks as a featured species group.

6.9.3.2 Recommendation

For the Kamloops pilot project, the following featured habitats are recommended for expanded coverage (R. Ritcey and D. Low, pers. comm.): riparian zones; snags; old growth[1]; down materials (logs, etc.); man-made habitats (e.g. rock piles, old barns, bridges); lakes and potholes[2]; cliffs, talus, and caves; and edges.

---

[1]old growth is a broad term for old coniferous forests; this habitat may be subdivided according to biogeoclimatic zone or major dominant species

[2]correct terminology and definitions are required to differentiate some wetland categories; existing classifications should be used

7 HABITAT HANDBOOK PROGRAM PROPOSAL

7.1 Introduction

The habitat handbook program goal has two objectives: 1) production of the habitat handbook and related products for wildlife; and 2) implementation of these products. The following chapter is a detailed outline of how the Kamloops pilot project will attempt to achieve these objectives. This pilot project has seven specific objectives:

1) explain and illustrate wildlife habitat concepts, planning levels and concepts, and management principles applicable to British Columbia (Section 7.2);
2) describe and illustrate a habitat classification system (Section 7.3);
3) document current knowledge on the relationships of all wildlife species in the pilot area to different habitat classes (Section 7.4);
4) describe and illustrate a habitat evaluation process(Section 7.5);
5) describe and illustrate strategies and opportunities for meeting wildlife objectives through vegetation management (Section 7.6);
6) provide some case history examples of using the species-habitat relationships approach to wildlife management in managed ecosystems (Section 7.7); and,
7) implement the pilot habitat handbook (Section 7.8).

7.2 Concepts and Principles

This section of the handbook will fulfill the need to have a common vocabulary among resource agencies to ensure full understanding of each others' disciplines. This entails a description of common habitat and ecological concepts, different levels of integration of information (e.g. planning levels), planning concepts, and general management principles. Some of these have been described in this problem analysis. This section is essential to the full understanding and utilization of the proposed handbook. Table 20 lists some of the terminology that requires discussion; there may be some need to describe some within the text and all of them within a glossary.

This section of the handbook will provide the basic concepts of wildlife management systems operating on a common land base with timber and range management systems, in an effort to provide complementary rather than conflicting systems.

Table 20. Concept and principles terminology

A. Habitat/Ecological Concepts

- biogeography
- capability
- carrying capacity
- coefficients
- competition
- diversity
- driving forces
- ecological classification
- ecological stratification
- ecotone
- edge
- guilds
- habitat
- life forms
- life requisites
- limiting factors
- models matrices
- niche
- pattern
- productivity
- specific habitat elements
- stand condition
- state factors (key)
- structure
- succession
- wildlife

B. Management Principles

- communication
- conservation
- coordination/cooperation
- diversity (species richness)
- economic analysis
- fall down effect
- featured habitats
- featured species
- integration
- inventory (information acquisition)
- mitigation
- multiple use
- sustained yield
- vegetation management (range)
- vegetation management (silviculture)
- viable populations

C. Planning Concepts

- adaptive management
- alternative formulation/ objective setting
- analysis
- comprehensive mangement
- consumptive/nonconsumptive use
- decision-making
- evaluation
- incremental planning
- integration
- modeling
- monitoring
- optimization
- planning horizons
- resource allocation
- uncertainty/risk

D. Planning Levels

a. Environment - provincial
regional
subregional/strategic
wildlife management area
site specific project plans

b. Forests - provincial
regional
TSA/TFL
unit
subunit
operational

c. Interagency - folios
deferred area plans
CRMP's
referrals

7.3 Habitat Classification System

Criteria for selection of the habitat classification system and associated habitat attributes are given in Chapter 6. This section of the handbook will describe the classes of the system, provide links to other resource classification systems, and incorporate information that can be related to anticipated changes due to management activities. As well, relationships of wildlife to the habitat classes will be quantitatively evaluated by capability coefficients by season of use and life requisite. The description of each habitat class will incorporate information on the classification hierarchy, on dominant vegetation, and on structural aspects of the classes including size, form, canopy characteristics and understory characteristics. There will also be descriptions of the specific habitat elements (see Table 12).

7.4 Wildlife-Habitat Relationships

The wildlife-habitat relationships information base will be presented at the three levels described in Chapter 6: 1) a basic species-habitat model for all vertebrate species; 2) the more detailed models for species likely to be selected for management emphasis (management indicator species); and 3) more detailed models for habitats of special importance to management (featured habitats). The basic species-habitat relationships will link individual species to habitat attributes required to supply basic life requisites (for example, see Figures 12 and 14). This information can be organized in several formats, either by extracting subsets of habitat attributes to highlight certain wildlife-habitat features or by grouping species into guilds and relating these to sets of habitat attributes (for example, see Figures 15, 16 and 17). This section of the handbook will probably encompass several chapters; the actual species-habitat matrices will be contained in appendices. Also, the text could illustrate the range of options available and the organization of the data. The more detailed models for management indicator species and featured habitats should be contained in a number of individual chapter documents. This section can be considered to be the data base upon which the following two sections, one planning and one tactical, are dependent.

7.5 Wildlife-Habitat Evaluation: The Planning Process

This section will describe and illustrate a habitat evaluation process based on data base of the wildlife-habitat relationships. The section will

include the descriptions and examples of the process of setting and evaluation of objectives related to wildlife habitats. It should be kept in mind that other resources should be following a similar approach; the second stage would be the integration of all resource objectives into a single land use plan.

In order to develop the planning process for wildlife habitat management, several connected planning actions are important; Figure 39 summarizes the process for habitat evaluation. The first step is a decision on the desired direction for wildlife management, based on present issues and concerns. This concept involves identification of diversity objectives and deciding upon selection criteria for featured species (see Section 6.11.2). The next stages develop an analysis of supply. A habitat inventory process is needed that will provide an areal dimension to the species-habitat relationships. The successional attributes of the habitat classification allow for quantification of potential as well as actual availability of habitat.

The habitat evaluation process provides quantitative data on usefulness of available habitat to species or groups of species of interest for the plan area. Based on this finite set of physically and biologically controlled options, and by incorporating social demands, alternative habitat objectives can be formulated. This is analagous to an analysis of the management situtation. Based on an evaluation of the cost/benefit of these objectives as well as the physical, biological and social aspects of implementing the alternatives, in cooperation with the other resource interests, it should be possible to complete the integration of resources into a management plan.

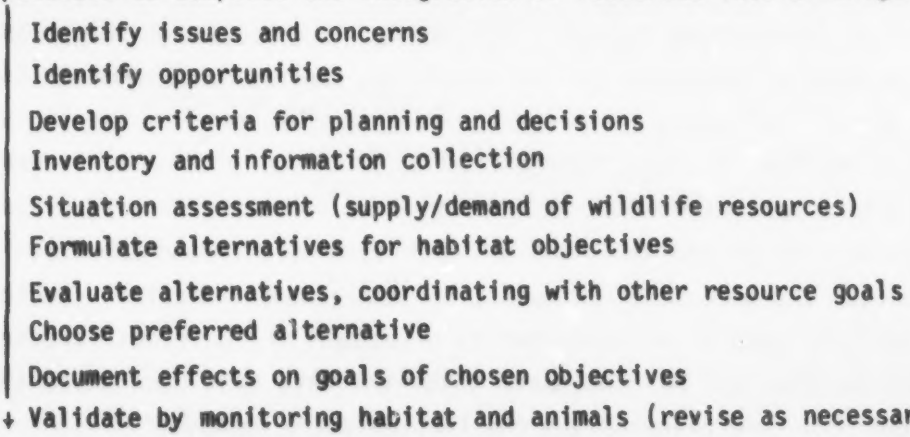

Identify issues and concerns
Identify opportunities
Develop criteria for planning and decisions
Inventory and information collection
Situation assessment (supply/demand of wildlife resources)
Formulate alternatives for habitat objectives
Evaluate alternatives, coordinating with other resource goals
Choose preferred alternative
Document effects on goals of chosen objectives
Validate by monitoring habitat and animals (revise as necessary)

Figure 39. Process of habitat evaluation (modified from U. S. Department of Agriculture, Forest Service 1979b)

Once the preferred alternative objectives are chosen, documentation on effects on the initial wildlife management goals is necessary. The entire process is validated by monitoring both habitat and animal to ensure that the correct evaluations were achieved; this allows for revision of alternatives if necessary and increases confidence in future mangement. A validation model is shown in Figure 40.

7.6 Vegetation Management

This section of the habitat handbook will describe and illustrate strategies and opportunities for meeting wildlife objectives through the various vegetation management systems presently utilized in British Columbia. A better understanding of how the forest or range manager may manipulate habitat is necessary for the wildlife biologist to assess the best means of reaching wildlife habitat objectives. This tactical chapter will be subdivided into a description of silvicultural and range management practices. These practices define the set of options available to the wildlife manager for achieving habitat objectives. Emphasis will be placed on management alterations that either advance or retard succession by modification of structure (see Figure 41 and 42); succession is really not advanced or retarded but the end result from a habitat viewpoint is thought to be similar.

Forest practices have been grouped into six categories by Bunnell and Eastman (1976:17):

1) Felling: regeneration systems, logging systems, residues
2) Site Preparation: slash burning, snag removal, scarification
3) Stand Establishment: species-choice, monocultures, herbicides, stand conversion, planting, seeding, rodent control
4) Stand Tending: spacing, thinning, fertilization
5) Stand Protection: fire suppression and exclusion, pesticides
6) General Management Considerations: rotation length, annual allowable cut, landscape pattern, road building.

These categories are not necessarily complete, but they can be used to generate a series of models of forest practice events that can be related to

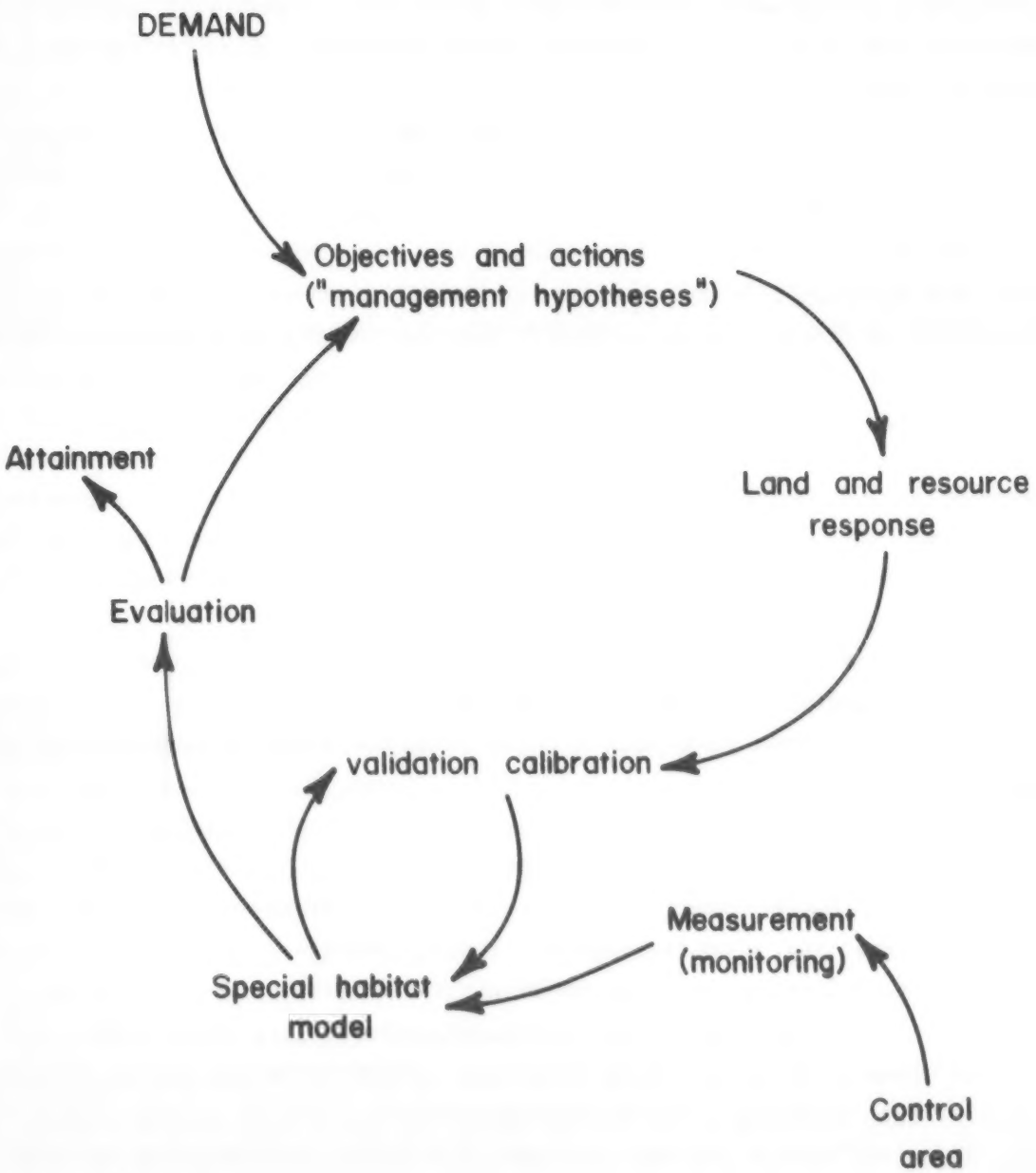


Figure 40. Validation model in habitat evaluation process.

time (e.g. rotation) (see Figure 43). These models can be tailored to fit the various forested habitat classes. For each practice described, there can be an explanation of how the practice alters habitat and therefore how it affects animals (see Figure 41). Included in the section will be a discussion of management area characteristics and scheduling of activities.

A similar approach is suggested for range management (grazing) systems. A discussion should include the principles of range management; options and flexibility of operation; allotment size and pattern; information on animal management, such as density, duration, scheduling, class of animal, and predator control; and improvement practices, such as seeding, fertilization, burning, fencing, salt, water development, and weed and brush control (see Figure 42).

The section on vegetation management should conclude with a summary of the interrelationships of wildlife, silviculture, and range management. It must be emphasized that other resource management activities provide opportunities to produce good wildlife habitat. There is a strong need to establish and verify these changes resulting from management practices in order to improve habitat.

7.7 Case Histories

This section will provide a series of "case history" examples that illustrate the use of the species-habitat models in the forest or range planning systems. These examples, either real or simulated, will not resolve the problems of actually incorporating wildlife habitat objectives in some multiple-resource plan; rather, they will show the means by which the data base can be utilized as a tool for assessing present and future options considering habitat values for both species richness and featured species management goals.

7.8 Implementation

This section will deal with the implementation of the data base and procedures of the wildlife habitat handbook. This will be a highly complex task, for it involves not only the development of the means for setting wildlife habitat objectives to meet species diversity goals and for better assessing total land management activities impacts on a wide variety of wildlife species, but also the development of a total integrated approach to land use planning. It should be kept in mind, though, that the main wildlife

Management action (forest):						
Shrub control:						
• Herbicides	▶	▶	▶	◀	◀	◀
• Mechanical control	◀	◀	NA	◀	◀	◀
Controlled burn:						
• Cold burn	◀	◀	▶	▶	◀	◀
• Hot burn	◀	◀	◀	◀	◀	◀
Fertilization	◀	▶	▶	▶	▶	O
Grazing and browsing (moderate rates):						
• Cattle and sheep	◀	▶	O	O	◀	◀
• Goats	O	◀	O	O	◀	◀
• Deer and elk	◀	▶	O	O	◀	◀
Planting:						
• Trees	▶	▶	NA	NA	▶	▶
• Shrubs	▶	◀	NA	NA	NA	NA
• Grasses-forbs	▶	◀	NA	▶	▶	O
Regeneration cut:						
• Clearcut	NA	NA	NA	◀	◀	◀
• Shelterwood	NA	NA	NA	▶	◀	◀
• Seed tree	NA	NA	NA	◀	◀	◀
Salvage	NA	NA	◀	◀	◀	◀
Thinning (including single tree selection harvest)	NA	▶	▶	▶	▶	O
▶ advances succession ◀ retards succession O no effect on succession NA not applicable	Grass-forb	Shrub-seedling	Pole-sapling	Young	Mature	Old growth
	Successional stage condition					

Figure 41. Anticipated changes in successional stage or condition because of management activities (from Thomas et al. 1979e:29).

Management action (range)					
• Weed control	◀	▶	▶	○	○
Brush control					
• Chemical	NA	◀	◀	NA	◀
• Mechanical	NA	◀	◀	NA	◀
• Biological	NA	◀	◀	NA	◀
Tree control					
• Chain and doze	NA	NA	NA	◀	◀
• Clearcut	NA	NA	NA	◀	◀
• Shelterwood	NA	NA	NA	◀	◀
• Thin	NA	NA	NA	◀	◀
• Salvage	NA	NA	NA	◀	◀
• Debris disposal	NA	NA	NA	◀	◀
Controlled burn					
• Cold burn	◀	◀	◀	○	◀
• Hot burn	◀	◀	◀	◀	◀
Seeding and plantations					
• Grasses and forbs	▶	◀	◀	◀	◀
• Shrubs	▶	○	○	▶	○
• Trees	▶	▶	▶	○	○
• Fertilization	○	◀▶	◀▶	◀▶	◀▶
Mechanical soil treatment					
• Pitting	◀	◀	◀	◀	◀
• Contouring	◀	◀	◀	◀	◀
Water					
• Water spreading	◀	◀	◀	◀	◀
• Drainage	▶	▶	▶	▶	▶
• Water development	◀	◀	◀	○	○
Grazing					
• Cattle	◀▶	◀▶	◀▶	○	○
• Horses	◀▶	◀▶	◀▶	○	○
• Sheep	◀▶	◀	◀	○	◀
Goats	◀▶	◀	◀	○	◀

▶ advances succession
◀ retards succession
○ no effect on succession
NA not applicable

Grass-forb | Low shrub | Tall shrub | Tree | Tree-shrub

Structural conditions

Figure 42. Anticipated changes in range-community structured conditions because of management activities (adapted from Maser et al. 1982).

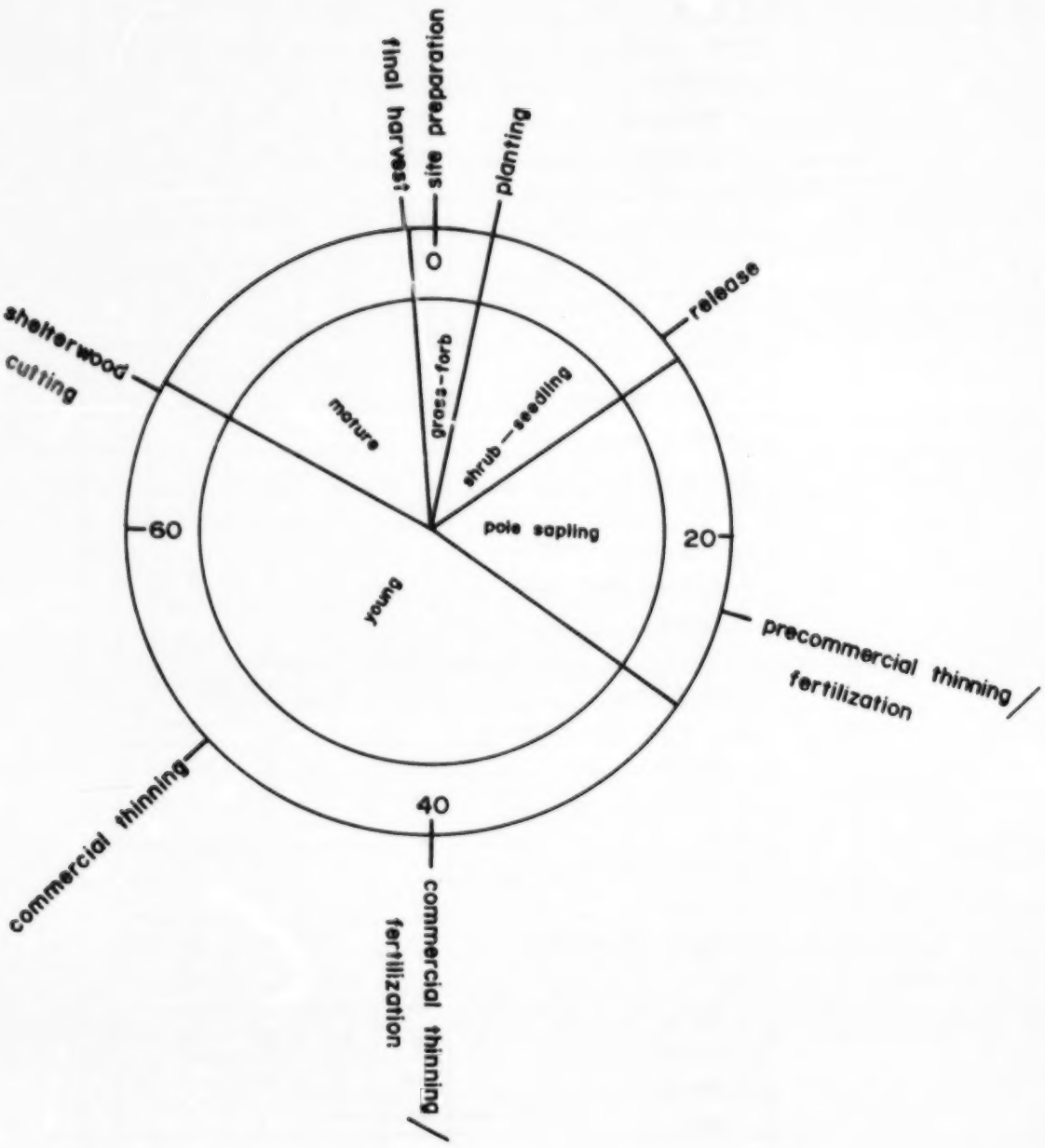


Figure 43. Hypothetical association of forestry practices to a generalized rotation cycle, related to successional stage conditions of Thomas (1979c).

habitat handbooks will be a tool that must then be utilized as part of a complex planning system. The implementation task will involve a number of functions, including:

1) development of new policies as needed;
2) adjustment of budgets, personnel, and work practices of the involved agencies as necessary;
3) conducting formal training of use of the handbook as a tool; and,
4) monitoring, evaluating, and revising as needed the use of new knowledge, concepts and procedures.

8 WORKING PLAN

8.1 Content

After decisions are made about the primary recommendations of the problem analysis, there are three major directions for future work:

1) development of the data base;
2) development of the procedures for using the data; and,
3) development of the process for integrating wildlife into public land, forest and range management.

The working plan is a document designed as a blueprint for the handbook development. The plan describes the technical detail that will be covered, scheduling (order and timing), participation, objectives, and projected costs for the wildlife habitat handbook project.

To develop the data base described necessary in Chapter 7, four activities must first take place:

1) complete a species list for the study area;
2) complete narratives for these species;
3) develop a habitat classification; and,
4) select management indicator species and featured habitats for the study area.
5) define set of specific habitat elements.

Then, based on the recommendations, organization of the data base will be implemented.

The development of use procedures will involve means by which habitat objectives are set, dependent upon the species management objectives: featured species, species diversity, or both. Included in this must be the means of projecting the species-habitat relationships through time in successional stages; preferably, this would be done by the use of some form of model that would follow changes in the forest range ecosystem through successional or management activities. This need has been identified as requiring more analysis, because the model must also be compatible with land management activities as well as with attributes of the habitat classification. This second direction will involve such items as setting minimum habitat objectives and standards, resource goals and objectives, and habitat condition standards.

The development of integration procedures is the second step in the planning process that requires a lot of effort in British Columbia. This involves such items as coordinating activity schedules, integrating stand or range unit prescriptions, and monitoring and revision of objectives.

8.2 Scheduling

The projected schedule for the completion of the problem analysis/ development of a working plan is:

1) July 5: distribute first draft of problem analysis to committee members
2) July 12: working meeting with committee to decide upon basic recommendations to be followed
3) July 13 - August 26: full edit of problem analysis by committee members; concurrently, Harcombe writing working plan based on preliminarily-accepted recommendations, with inputs from committee members
4) August 29-September 30: problem analysis revision
5) October 31 - December 30: submission of problem analysis to outside edit; complete first draft of working plan
6) March 15: make final edit changes to problem analysis print and distribute
7) submit working plan for committee edit by April 30, 1984
8) January 1, 1984 - December 31, 1984: based on detailed schedule in working plan, prepare handbook (all authors).

8.3 Concurrent Activities

If the major recommendations of the problem analysis are accepted, a number of items could be done concurrently with development of the working plan and editing of the problem analysis. These items include:

1) development of a habitat classification;
2) development of species notes using this habitat classification;
3) production of a standards/products guide ("dictionary") for species notes;
4) problem analysis on use of computer for storing and manipulating data;
5) compilation of species listing for handbook area;
6) develop policy for management indicator species/habitats in British Columbia;
7) choose management indicator species for pilot handbook area;
8) develop guide for production of management indicator species chapters;
9) problem analysis on forest successional modeling for British Columbia;

10) investigate link to various data systems used in forestry, range, and habitat inventory;
11) finalize list and definitions for specific habitat elements.

8.4 Authorship

Except for the concept of using existing staff for authors whenever possible, authorship has only been briefly considered. Final choices will depend primarily upon time commitment various agencies are willing and able to make, and availability of suitable staff. Some suggestions for specific parts of the handbook project (incomplete) are (primary coordinators only are listed; they may or may not become primary authors):

1) concepts and principles: Rick Ellis/Don Eastman
2) species notes: Wayne Campbell
3) habitat classification: Andrew Harcombe/Fraser Russell
4) species/habitat matrices: Wayne Campbell/Andrew Harcombe
5) management indicator species (incomplete):
   - mule deer: Dave Low
   - moose: Ralph Ritcey
   - burrowing owl: Rick Howie
   - yellow badger: Dave Low
   - fur-bearer (marten): Linda Stordeur/Ralph Archibald
   - bighorn sheep: Brian Fuhr/Dennis Demarchi
   - rattlesnake: Pat Gregory/Stan Orchard
6) featured habitats (incomplete):
   - edges: Andrew Harcombe
   - potholes and lakes: Ducks Unlimited
   - snags: Jerry Korrell/Dave Low
   - riparian zones: Barb Thompson
7) evaluation process for data base utilization, including h a b i t a t objectives: Don Eastman/Brian Nyberg
8) silvicultural systems: Bernie Ivanco
9) range management systems: Rick Tucker/Dwayne Brooks (or Tom Wallace, retired: contract ?)

10) integration: Rick Ellis

The choice of two technical editors (Don Eastman and Rick Ellis) with a coordinator/editor-in-chief (Andrew Harcombe) should ensure continuity and consistency with further handbooks.

8.5 Research

At this time, no formal research is anticipated for the habitat handbook per se; it will be primarily based on state-of-the-art knowledge. However, some components of the handbook may require some research; this should probably be left to agency control. Much of the wildlife research presently underway, such as the Integrated Wildlife-Intensive Forestry Research (IWIFR) program and regional research project will contribute data and knowledge, especially for some of the featured species and habitats. The handbook needs may help guide the direction of research; there is already a stated desire from universities to cooperate using graduate student levels (A. Harestad, pers. comm.; F. Bunnell, pers. comm.).

8.6 Budget

Recent developments in the government budget restraint program will likely modify agency commitments planned for the 1983/84 budget year. There are strong indications that the bulk of the work load will be carried with existing staff, at the same time minimizing operational expenditures. The working plan will attempt to suggest options that will be compatible with existing budgetary guidelines (e.g., minimize travel or new staff position).

9 RECOMMENDATIONS

1) Wildlife habitat handbooks should be prepared for all of British Columbia as cost-effective aids to achieving the two primary provincial wildlife management goals and assisting other resource managers in understanding habitat requirements of terrestrial wildlife.
2) An in-depth study of possibilities for inclusion of fish and aquatic habitats into the species-habitat relationships approach should be examined by problem analysis.
3) The province should be divided into eight handbook areas, based on wildlife ecosystem regions and subregions.
4) The pilot project study area should be the Thompson Plateau and Okanagan Ranges wildlife ecosystem regions, to be called the Southern Interior handbook.
5) Authorship of handbook components should be done by existing appropriately qualified government staff whenever possible, provided firm time commitments can be guaranteed.
6) Other sources of expertise, such as in universities, should be used.
7) The initial project should have a single coordinator/editor-in-chief (A. Harcombe) and two technical editors (D. Eastman and R. Ellis) with Harcombe as the overall coordinator of handbook activities.
8) The handbook should be published in multiple volume format so that each chapter can be printed as it becomes ready.
9) The data base should be initially available in hard copy.
10) A problem analysis should be carried out on possibilities of setting up a wildlife habitat data base on a computer-assisted system for fast access of basic data; existing United States programs should be considered to save time and money (e.g. Quick Query).
11) Full support should be given to the "B. C. Vertebrate Atlas" program of the B. C. Provincial Museum to produce species notes including information on:
    a) taxonomy
    b) status, abundance, and seasonality
    c) distribution/habitat
    d) special habitat requirements
    e) breeding
    f) territory/home range
    g) food habits
    h) references

i) other ecological/management features.

12) A basic level species/habitat model should be developed, generally for use in species richness or diversity management planning at a subregional or smaller scale, that will:

a) be complete for all species in all habitats

b) use a habitat classification that follows the stated selection criteria

c) include successional stages in the habitat classification, tying these to ecological or taxonomic habitat units

d) include canopy closure for the dominant layer in the habitat classification, initially divided into the following classes:
sparse cover (0-25%), moderate cover (26-65%), and dense cover (66-100%)

e) include specific habitat elements, for essential or preferred habitat attributes not included in the habitat classification

f) include consideration of the wildlife species-habitat relationships for the life requisites of reproduction, feeding, and designated special needs

g) include capability coefficients (high, moderate, low, not used) on a species-specific basis for subdivisions of each habitat class (structural stage and canopy closure)

h) include coefficients of importance on a species-specific basis for each specific habitat element

i) include a season of use designation for each habitat attribute, using combinations of seasons (spring, summer, fall, mild or severe winter)

j) be accessible from a computer-based system.

13) Detailed models and specific management documents should be developed, generally for use in management and planning for management indicator species at subregional or larger scale, that will:

a) be completed for all management indicator species in the planning unit, selected from the total species list using a standard set of criteria

b) include quantitative population data suitable for detailed monitoring of habitat manipulation-species responses

c) be complete for selected habitats and/or specific habitat elements that are especially important to a group of species, with an emphasis on management alternatives to improve suitability and availability

14) The habitat handbook should follow the suggested detailed outline (Chapter 7). Production should be ranked into three parts:
   a) organize the data base (Sections 7.2, 7.3 and 7.4), develop diversity objectives, develop documents on management indicator species and habitats, and describe opportunities for vegetation management
   b) develop a habitat evaluation and planning coordination process
   c) develop a program for implementing the use of the handbook into the land management and planning system
15) Conduct a problem analysis to select the most appropriate simulation model for modeling plant community changes through time and changes due to management activities.
16) Other desirable recommendations, though beyond the scope of this problem analysis are listed here because they are relevant for the process of wildlife management in multiple use lands, and the handbook should aid in their resolution. It is recommended that one should:
   a) better define wildlife management goals because they are poorly stated and lack any supporting definition or explanation of important concepts, especially regarding population viability and diversity
   b) develop a better land use planning process by providing provincial and regional guidelines for overall land planning, ranking resource values and capabilities
   c) direct a greater effort towards management of species richness (diversity), with some form of standardization of management indicator species selection for featured species management.

10. REFERENCES

Aggus, L.R., and W.M. Bivin. 1982. Habitat suitability index models: regression models based on harvest of coolwater and coldwater fishes in reservoirs. FWS/OBS-82/10.25. USDI Fish Wildl. Serv., Fort Collins, Colo. 38 p.

Airola, D.A. (ed.). 1980a. California wildlife habitat relationships program: northeast interior zone. Volume 2 - reptiles and amphibians. Unpublished report. USDA For. Serv., Pacific Southwest Region, Calif. 137 p.

Airola, D.A. (ed.). 1980b. California wildlife habitat relationships program: northeast interior zone. Volume 3 - birds. Unpublished report. USDA For. Serv., Pacific Southwest Region, Calif. 590 p.

Airola, D.A. (ed.). 1980c. California wildlife habitat relationships program: northeast interior zone. Volume 4 - mammals. Unpublished report. USDA For. Serv., Pacific Southwest Region, Calif. 255 p.

Alaback, P.B. 1982. Successional dynamics of understory vegetation following logging in the Sitka spruce - western hemlock forests of southeast Alaska: implications for management. Unpublished report. USDA For. Serv., Region 10, Juneau, Alaska. 20 p.

Allen, A.W. 1982a. Habitat suitability index models: beaver. FWS/OBS-82/10.30. USDI Fish Wildl. Serv., Fort Collins, Colo. 20 p.

Allen, A.W. 1982b. Habitat suitability index models: fox squirrel. FWS/OBS-82/10.18. USDI Fish Wildl. Serv., Fort Collins, Colo. 11 p.

Allen, A.W. 1982c. Habitat suitability index models: gray squirrel. FWS/OBS-82/10.19. USDI Fish Wildl. Serv., Fort Collins, Colo. 11 p.

Allen, A.W. 1982d. Habitat suitability index models: marten. FWS/OBS-82/10.11. USDI Fish Wildl. Serv., Fort Collins, Colo. 9 p.

Anderson, R.C., O.L. Loucks, and A.M. Swain. 1969. Herbaceous response to canopy cover, light intensity, and throughfall precipitation in coniferous forests. Ecology 50 (2):255-263.

Annas, R.M., and R. Coupe (eds.). 1979. Biogeoclimatic zones and subzones of the Cariboo Forest Region. Ministry of Forests, Victoria, B. C. 103 p.

Anonymous. 1982. Proposed Forest Service fish habitat relationships system. Draft proposal. Fish habitat relationships Steering Committee, Boise, Idaho. 21 p.

Arno, S.F. 1982. Classifying forest sucession on four habitat types in western Montana. p.54-62 In J. E. Means (ed.). Forest succession and stand development research in the Northwest. Proceedings of the Symposium held 26 March 1981, Corvallis, Oregon. Forest Research Laboratory, Oregon State University, Corvallis, Oreg. 170 p.

Bailey, R.G. 1976. Ecoregions of the United States. USDA For. Serv. Fort Collins, Colo. Map.

Bailey, R.G. 1980. Description of the ecoregions of the United States. USDA For. Serv. Misc. Publ. 1391. Rocky Mountain For. and Range Exp. Stn., Fort Collins, Colo. 77 p.

Bailey, R.G. 1982. Classification systems for habitat and ecosystems. p. 16-26 In Research on fish and wildlife habitat. U.S. Environmental Protection Agency EPA 600/8-82-022, Washington, D.C. 248 p.

Bailey, R.G., and C.T. Cushwa. 1981. Ecoregions of North America after the classification of J.M. Crowley. FWS/PBS-81/29 (1:12,000,000 map). USDI Fish Wildl. Serv., Washington, D.C. 1 p.

Bain, M.B., and J.L. Bain. 1982. Habitat suitability index models: coastal stocks of striped bass. FWS/OBS-82/10.1. USDI Fish Wildl. Serv., Office of Biological Services, Washington, D.C. 29 p.

Barrett, R.H., and H. Salwasser. 1982. Adaptive management of timber and wildlife habitat using DYNAST and wildlife-habitat relationships models. Proc. W. Assoc. Fish and Wildl. Agencies 61:in press.

Bartels, R., J.D. Dell, R. Knight, and G. Schafer. 1982. Dead and down woody materials. In R. Brown (ed.). Oregon-Washington westside wildlife-forest relationships. Unpublished draft. USDA For. Serv., Portland, Oreg. [50 p.].

Barton, M.A. 1981. WHR Handbook. Unpublished memo. USDA For. Serv., Region 10, Alaska.

Basey, H.E., and D.A. Sinclear. 1980. Amphibians and reptiles. p. 13-72 In J. Verner and A.S. Boss (tech. coordinators). California wildlife and their habitats: western Sierra Nevada. USDA For. Serv. Gen. Tech. Rep. PSW-37. Pacific Southwest For. and Range Exp. Stn., Berkeley, Calif. 439 p.

B.C. Ministry of Environment. [1980?]. Ministry of Environment: goals, objectives, programs. Unpublished report. Victoria, B.C. 48 p.

B.C. Ministry of Environment. 1981. Discussion paper on a new wildlife act. Victoria, B.C. 38 p.

B.C. Ministry of Environment. Fish and Wildlife Branch. 1979. Proposed wildlife management plan for British Columbia. Unpublished report. Dept. of Conservation, Victoria, B.C. 89 p.

B.C. Ministry of Environment, Fish and Wildlife Branch. 1980. Summary of public comment on the proposed wildlife management plan for British Columbia. Unpublished report. Victoria, B.C. 55 p.

B.C. Ministry of Environment, Fish and Wildlife Branch. 1982a. British Columbia hunting regulations synopsis: 1982-1983. Victoria, B.C. 60 p.

B.C. Ministry of Environment, Fish and Wildlife Branch. 1982b. The Thompson-Nicola (Region 3) regional wildlife management plan. Unpublished report. Victoria, B.C. 169 p.

B.C. Ministry of Environment, Surveys and Mapping Branch. 1981. Regional boundaries for the Ministry of Environment. Victoria, B.C. Map.

B.C. Ministry of Environment, Surveys and Mapping Branch. 1982. Lands and Housing Regional Operations Division Regions and Districts. Victoria, B.C. Map.

B.C. Ministry of Environment, Surveys and Resource Mapping Branch. 1982. Biophysical vegetation regions of British Columbia. Terrestrial Studies Section, Victoria, B.C. Map.

B.C. Ministry of Forests. 1980. Lillooet timber supply area report: December 1980 - Kamloops Forest Region. Unpublished report. Kamloops, B.C. 43 p.

B.C. Ministry of Forests. 1981. Kamloops timber supply area yield analysis report: May 1981 - Kamloops Forest Region. Unpublished report. Kamloops, B.C. 60 p.

B.C. Ministry of Forests. 1983. Ministry of Forests statement on integrated resource use. Unpublished document. Released 04 Feb. 1983. Victoria, B.C. 3 p.

B.C. Ministry of Forests, Information Services Branch. 1980a. Five-year forest and range resource program. Victoria, B.C. 31 p.

B.C. Ministry of Forests, Information Services Branch. 1980b. Forest and range resource analysis report. Victoria, B.C. 27 p.

B.C. Ministry of Forests, Information Services Branch. 1980c. Forest and range resource analysis technical report volumes 1 and 2. Victoria, B.C. 802 p. + app.

B.C. Ministry of Forests, Kamloops Region. 1982a. Coordinated resource management and range plan areas. Planning Section, Forestry Division, Kamloops, B.C. Map.

B.C. Ministry of Forests, Kamloops Region. 1982b. Folio plan areas in the Kasmloops Forest Region. Planning Section, Forestry Division, Kamloops, B.C. Map.

B.C. Ministry of Forests, Planning Division. 1978. Forest planning handbook. Unpublished report. Victoria, B.C. 80 p. + app.

B.C. Ministry of Forests, Planning Division. 1979. Provincial forest: a discussion paper prepared by the Planning Division of the B.C. Forest Service. Unpublished report. Victoria, B.C. 46 p.

B.C. Ministry of Forests, Range Management Branch and Inventory Branch. 1982. Ministry of Forests range inventory program: an initial approximation. Unpublished report. Victoria, B.C. [n.p.].

B.C. Ministry of Forests, Research Branch. 1980. Biogeoclimatic zones of British Columbia. Victoria, B.C. map.

B.C. Public Service Commission, Staff Development and Safety Programs. 1981a. Ministry of Environment. p. 94-101 In Organization of the B.C. public service. Victoria, B.C.

B.C. Public Service Commission, Staff Development and Safety Programs. 1981b. Ministry of Forests. p. 116-141 In Organization of the B.C. public service. Victoria, B.C.

B.C. Public Service Commission, Staff Development and Safety Programs. 1981c. Ministry of Lands, Parks and Housing. p. 202-210 In Organization of the B.C. public service. Victoria, B.C.

Beebe, F.L. 1974. Field studies of the Falconiformes of British Columbia: vultures, hawks, falcons, eagles. Occasional Papers of the British Columbia Provincial Museum No. 17. Department of Recreation and Conservation, Victoria, B.C. 163 p.

Benson, W., K. Child, D. Eastman, P. Haley, D. Hebert, B. Pendergast, M. Rose, and B. Saunders. 1982. Developing an integrated data system for wildlife management in B.C. Part 1: general framework and the existing system. Unpublished report. Fish Wildl. Branch, Ministry of Environment, Victoria, B.C. [56 p.].

Bowers, W., B. Hosford, A. Oakley, and C. Bond. 1979. Native trout. In J. W. Thomas and C. Maser (tech. eds.). Wildlife habitats in managed rangelands: the Great Basin of southeastern Oregon. USDA For. Serv. Gen. Tech. Rep. PNW-84. Pacific Northwest For. and Range Exp. Stn., LaGrande, Oreg. 16 p.

Boyce, S.G. 1978. Management of forests for timber and related benefits (DYNAST-TM). USDA For. Serv. Res. Pap. SE-184. Southeast For. Exp. Stn., Ashville, N.C. 140 p.

Boyce, S.G. 1980. Management of forests for optimal benefits (DYNAST-OB). USDA For. Serv. Res. Pap. SE-204. Southeastern For. Exp. Stn., Asheville, N.C. 42 p.

Brooke, R.C., E.B. Peterson, and V.J. Krajina. 1970. The subalpine mountain hemlock zone. Ecology of western North America 2(1): 153-349.

Brown, E.R. 1980. Oregon-Washington westside wildlife-forest relationships. Unpublished report. USDA For. Serv., Washington, D.C. [290 p.].

Bunnell, F.L., and D.S. Eastman. 1976. Effects of forest management practices on wildlife in the forests of British Columbia. p. 631-689 IN Proc. Div. I XVI IUFRO World Congress, Oslo, Norway.

Bunnell, F.L., R. Ellis, S. Stevenson, and D.S. Eastman. 1978. Evaluating ungulate populations and range in British Columbia. Trans. N. Amer. Wildl. Natur. Resour. Conf. 43:311-322.

Bureau of Governmental Research and Service, University of Oregon. 1982. Old growth forests: a balanced perspective. Proceedings of a Conference. Eugene, Oreg. 147 p.

Campbell, R.W., H.R. Carter, C.D. Shepard, and C.J. Guiguet. 1979. A bibliography of British Columbia ornithology. B.C. Provincial Museum heritage record no. 7, Ministry of the Provincial Secretary and Government Services, Victoria, B.C. 185 p.

Campbell, R.W., and A.H. Harestad. 1981. Proposal for an atlas of British Columbia vertebrates (amphibians, reptiles, birds, and mammals). Unpublished report. Vertebrate Zoology Division, B.C. Provincial Museum, Victoria, B.C. 21 p.

Campbell, R.W., M.G. Shepard, B.M. Van Der Raay, and P.T. Gregory. 1982. A bibliography of Pacific Northwest herpetology. B.C. Provincial Museum heritage record no. 14, Ministry of the Provincial Secretary and Government Services, Victoria, B.C. 152 p.

Canada Fisheries and Environment, Canadian Wildlife Service. 1978. List of birds protected in Canada under the Migratory Birds Convention Act. 6th edition. Canadian Wildlife Service Occasional Paper No. 1, Ottawa, Ont. 40 p.

Capen, D.E. (ed.). 1981. The use of multivariate statistics in studies of wildlife habitat. USDA For. Serv. Gen. Tech. Rep. RM-87. Rocky Mountain For. and Range Exp. Stn., Fort Collins, Colo. 249 p.

Capp, J.C., D.L. Wills, and M.L. Larson. 1982. Acheiving wildlife goals on National Forest System lands through silvicultural practices. p. 303-313 In Trans. 1982 An. Conf. West. Assoc. Fish and Wildl. Agencies. Las Vegas, Nevada (in press).

Carpenter, J.R. 1956. An ecological glossary. Hafner Publ. Co., New York, N.Y. 306 p. + App.

Casner, W.B., B. Kulongowski, D.R. Patton, and S.J. Pinkerton. 1978. RUN WILD for the UNIVAC 1100 Series: implementation and maintenance. USDA For. Serv. Gen. Tech. Rep. RM-51A. Rocky Mountain For. and Range Exp. Stn., Fort Collins, Colo. 31 p.

Cattelino, P.J., I.R. Noble, R.O. Slatyer, and S.R. Kessell. 1979. Predicting the multiple pathways of plant succession. Environ. Manage. 3(1):41-50.

Chamberlin, T.W. 1982. Influence of forest and rangeland management on anadromous fish habitat in western North America: timber harvest. USDA For. Serv. Gen. Tech. Rep. PNW-136. Pacific Northwest For. and Range Exp. Stn., Portland, Oreg. 30 p.

Chan, B. 1982. Management of cavity dwelling wildlife in the Dewdrop area, Kamloops, British Columbia. Unpublished report. Dept. of Biological Sciences, Simon Fraser University, Vancouver, B.C. 51 p.

Coulombe, H.N. 1978. Toward an integrated ecological assessmet of wildlife habitat. p. 5-23 In H.G. Lund, V.J. LaBau, P.F. Ffolliott, and D.W. Robinson (tech. coordinators). Integrated inventories of renewable natural resources: proceedings of the workshop, January 9-12, 1978. USDA For. Serv. Gen. Tech. Rep. RM-55, Fort Collins, Colo. 482 p.

Cowan, I. McT., and C.J. Guiguet. 1965. The mammals of British Columbia, 3rd edition (revised). Handbook No. 11. British Columbia Provincial Museum, Department of Recreation and Conservation, Victoria, B.C. 414 p.

Crowley, J. 1967. Biogeography. Can. Geog. 11(4):312-326.

Damon, B., M. Quintana, and C. Sundstrom. 1982. Users manual - system 2000 (S2K). In Wildlife/habitat relationships for national forests in Alaska. Unpublished report. USDA For. Serv., Region 10, Juneau, Alaska. 40 p.

Daubenmire, R. 1968. Plant communities: a textbook of plant synecology. Harper and Row, Publishers, New York, N.Y. 300 p.

Dealy, J.E., D.A. Leckenby, and D.M. Concannon. 1981. Plant communities and their importance to wildlife. In J.W. Thomas and C. Maser (tech. eds.). Wildlife habitats in managed rangelands: the Great Basin of southeastern Oregon. USDA For. Serv. Gen. Tech. Rep. PNW-120. Pacific Northwest For. and Range Exp. Stn., LaGrande, Oreg. 66 p.

DeGraff, R.M. (tech. coordinator). 1980. Workshop proceedings of management of western forests and grasslands for nongame birds. USDA For. Serv. Gen. Tech. Rep. INT-86. Intermountain For. and Range Exp. Stn., Rocky Mountain For. and Range Exp. Stn., and Intermountain Region, Ogden, Utah. 535 p.

DeGraaf, R.M., and D.D. Rudis. 1981. Forest habitat for reptiles and amphibians of the northeast. USDA For. Serv., Northeastern For. Exp. Stn. and Eastern Region, Milwaukee, Wis. 239 p.

DeGraaf, R.M., G.M. Witman, and D.D. Rudis. 1981. Forest habitat for mammals of the northeast. USDA For. Serv., Northeastern For. Exp. Stn. and Eastern Region, Milwaukee, Wis. 182 p.

Demarchi, D. 1982. Biotic regions/subregions of British Columbia. Terrestrial Studies Section, Ministry of Environment, Victoria, B.C. map.

Demarchi, D.A., B. Fuhr, B.C. Pendergast, and A.C. Stewart. 1983. Wildlife capability classification for British Columbia: an ecological (biophysical) approach for ungulates. Unpublished report. Surveys and Resource Mapping Branch, Wildlife Evaluation Unit, Victoria, B.C. [57 p + app.].

Demarchi, D.A., and B.A. Pendergast. 1983. Problem analysis: biotic regions of British Columbia - an ecological land classification for fauna. Unpublished draft. Terrestrial Studies Section, Surveys and Resource Mapping Branch, Ministry of Environment, Victoria, B.C. 16 p.

Dick, J. 1981. Strategic planning for wildlife in British Columbia. Unpublished report. Planning Branch, Ministry of Environment, Victoria, B.C. 15 p.

Dick, J.H., D.E. Phelps, D.M. Herbert, and F.E. Harper. 1977. Habitat management: objectives and policy for habitat conservation and management programmes in B.C. Unpublished report. Fish and Wildlife Branch, Ministry of Recreation and Conservation, Victoria, B.C. 30 p.

Dickson, J.G., and R.N. Conner. 1978. Guidelines for authorship of scientific articles. Wildl. Soc. Bull. 6(4):260-261.

Dodd, C.J.H., A. McLean, and V.C. Brink. 1972. Grazing values as related to tree-crown covers. Can. J. Forest Res. 2(3):185-189.

DuBrock, C.W., D.N. Gladwin, W.T. Mason, Jr., and C.T. Cushwa. 1981. State-of-the-art of fish and wildlife species information systems in the United States. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 46:156-170.

Environment and Land Use Technical Committee. 1977. Guidelines for regional resource management committees. Unpublished report. Victoria, B.C. 5 p.

Evans, K.E., and R.A. Kirkman. 1981. Guide to bird habitats of the Ozark Plateau. USDA For. Serv. Gen. Tech. Rep. NC-68. North Central For. Exp. Stn., St. Paul, Minn. 79 p.

Everest, F.H., N.B. Armantrout, S.M. Keller, W.D. Parante, J.R. Sedell, T.E. Nickelson, J.M. Johnston, and G.N. Haugen. 1982. Salmonids. In R. Brown (ed.). Oregon-Washington westside wildlife-forest relationships. Unpublished draft. USDA For. Serv., Portland, Oreg. [110 p.].

Everest, F.H., and R.D. Harr. 1982. Influence of forest and rangeland management on anadromous fish habitat in western North America: silvicultural treatments. USDA For. Serv. Gen. Tech. Rep. PNW-134. Pacific Northwest For. and Range Exp. Stn., Portland, Oreg. 19 p.

Eyre, F.H. (ed.). 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, D.C. 135 p.

Farmer, A.H., M.J. Armbruster, J.W. Terrell, and R.L. Schroeder. 1982. Habitat models for land-use planning: assumptions and strategies for development. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 47:47-56.

Ffolliott, P.F., and W.P. Clary. 1982. Understory-overstory vegetation relationships: an annotated bibliography. USDA For. Serv. Gen. Tech. Rep. INT-136, Intermountain For. and Range Exp. Stn., Ogden, Utah. 39 p.

Ford-Robertson, F.C. (ed.). 1971. Terminology of forest science, technology practice and products. Society of American Foresters, Washington, D.C. 349 p.

Forsman, E.D., K.M. Horn, and J.D. Mires. 1981. Habitat characteristics and management recommendations for spotted owls: western Oregon and Washington. In R. Brown (ed.). Oregon-Washington westside wildlife-forest relationships. Unpublished draft. USDA For. Serv., Portland, Oreg. [20 p.].

Foster, B. 1980. The role of Ecological Reserves in protecting threatened species and habitats in British Columbia. p. 23-27 In R. Stace-Smith, L. Johns, and P. Joslin (eds.). Threatened and endangered species and habitats in British Columbia and the Yukon: proceedings of the symposium held in Richmond, B.C., March 8 and 9, 1980. B.C. Ministry of Environment, Fish and Wildlife Branch, Victoria, B.C. 302 p.

Foubister, L.J. 1979. Fish and Wildlife Branch involvement in referral systems. Unpublished report. Habitat Protection Section, Fish and Wildlife Branch, Ministry of Environment, Victoria, B.C. 47 p.

Franklin, J.F., and C.T. Dyrness. 1973. Natural vegetation of Oregon and Washington. USDA For. Serv. Gen. Tech. Rep. PNW-8. Pacific Northwest For. and Range Exp. Stn., Portland, Oreg. 417 p.

Garrison, G.A., A.J. Bjugstad, D.A. Duncan, M.E. Lewis, and D.R. Smith. 1977. Vegetation and environmental features of forest and range ecosystems. USDA Handbook 477, Washington, D.C. 68 p.

Grenfell, W.E., Jr., H. Salwasser, and W.F. Laudenslayer, Jr. 1982. The California wildlife/fish habitat relationships system. Cal-Neva Wildl. Trans. (January):27-33.

Hall, F.C. 1973. Plant communities of the Blue Mountains in eastern Oregon and southeastern Washington. USDA For. Serv. Reg. 6 Area Guide 3-1, Portland, Oreg. 62 p.

Hall, F.C. 1980. Plant communities and stand conditions. In R. Brown (ed.). Oregon-Washington westside forest-wildlife habitat relationships. Unpublished draft. USDA For. Serv., Washington, D.C. [14 p.].

Hall, F.C. and J.W. Thomas. 1979. Silvicultural options. p. 128-147 In J.W. Thomas (tech. ed.). Wildlife habitats in managed forests: the Blue Mountains of Oregon and Washington. USDA For. Serv. Agric. Handbook No. 553, Washington, D.C. 512 p.

Hamilton, E. 1983. A proposal for a problem analysis of the classification of succesional ecosystems within the BCMF Research Branch ecosystem classification program. Draft memo. Research Branch, Ministry of Forests, Victoria, B.C. 7 p.

Hanley, T.A. 1981. Big game-forest management relationships in southeast Alaska: problem analysis. Unpublished report. USDA For. Serv., Pacific Northwest For. and Range Exp. Stn., Juneau, Alaska. 89 p.

Hanley, T.A., and J.L. Page. 1982. Differential effects of livestock use on habitat structure and rodent populations in Great Basin communities. Calif. Fish and Game 68(3):160-173.

Hanson, H.C. 1962. Dictionary of ecology. Philos. Libr., New York, N.Y. 382 p.

Harcombe, A.P. 1981a. Biophysical forest zones of Vancouver Island. Terrestrial Studies Branch, Ministry of Environment, Kelowna, B.C. 7 maps.

Harcombe, A.P. 1981b. Data elements required for a wildlife habitat model: a discussion paper. Draft working report. Assessment and Planning Division, Ministry of Environment, Kelowna, B.C. 20 p.

Harcombe, A.P., C.E. Thompson, and R.F. Ferster. 1980. Vegetation of the Pine-Moberly area (93P/13, 14, 15;94A/2,3,4). Working report. Terrestrial Studies Branch, Ministry of Environment, Kelowna, B.C. 23 p.

Hare, F.K., and M.K. Thomas. Climate Canada. John Wiley and Sons Canada Limited, Toronto, Ont. 230 p.

Harris, L.D., C. Maser, and A. McKee. 1982. Patterns of old growth harvest and implications for cascades wildlife. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 47:374-392.

Hays, R.L., C. Summers, and W. Seitz. 1981. Estimating wildlife habitat variables. FWS/OBS-81/47. USDI Fish Wildl. Serv., Fort Collins, Colo. 111 p.

Henderson, J.A. 1982. Succession on two habitat types in western Washington. p. 80-86 In J.E. Means (ed.). Forest succession and stand development research in the Northwest. Proceedings of the Symposium held 26 March 1981, Corvallis, Oregon. Forest Research Laboratory, Oregon State University, Corvallis, Oregon. 170 p.

Hickman, T., and R.F. Raleigh. 1982. Habitat suitability index models: cutthroat trout. FWS/OBS-82/10.5. USDI Fish Wildl. Serv., Fort Collins, Colo. 38 p.

Hoekstra, T.W., J.W. Thomas, M.R. Lennartz, and D.P. Worley. 1981. Managing of federal lands for production and use of wildlife and fish. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 46:336-344.

Holland, S.S. 1964. Landforms of British Columbia: a physiographic outline. Bulletin No. 48. B.C. Department of Mines and Petroleum Resources, Victoria, B.C. 138 p. + map.

Holling, C.S. 1982. Science for public policy: highlights of adaptive environmental assessment and management. p. 78-91 In W.T. Mason, Jr. (ed.). Research on fish and wildlife habitat. Office on Research and Development, U.S. Environmental Protection Agency, Washington, D.C. 248 p.

Hurley, J.F., and E.S. Asrow. 1980. Western Sierra wildlife/habitat relationships computer use manual. Unpublished report. USDA For. Serv., Pacific Southwest Region, Calif. 155 p.

Hurley, J.F., H. Salwasser, and K. Shimamoto. 1982. Fish and wildlife habitat capability models and special habitat criteria. Cal-Neva Wildl. Trans. (January):40-48.

Inkley, D.B., and S.H. Anderson. 1982. Wildlife communities and land classification systems. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 47:73-81.

Inselberg, A.E., K. Klinka, and C. Ray. 1982. Ecosystems of MacMillan Park on Vancouver Island. Land Management Report Number 12. Ministry of Forests, Vancouver, B.C. 113 p.

Jameson, D.A. 1967. The relationship of tree overstory and herbaceous understory vegetation. J. Range Manage. 20:247-249.

Jasikoff, T.M. 1982. Habitat suitability index models: ferruginous hawk. FWS/OBS-82/10.10. USDI Fish Wildl. Serv., Fort Collins, Colo. 18 p.

Johnson, W., D. Godtel, R. Evans, and B. Burbridge. [n.d.]. Wildlife coordination outputs: diversity analysis system and reporting procedure for Region 1. Unpublished report. USDA For. Serv., Northern Region, Missoula, Mont. 20 p.

Kessell, S.R. 1979. Gradient modeling: resource and fire management. Springer-Verlag, New York. 432 p.

Kindschy, R.R., C. Sundstrom, and J.D. Yoakum. 1982. Pronghorns. In J.W. Thomas and C. Maser (tech.eds.). Wildlife habitats in managed rangelands: the Great Basin of southeastern Oregon. USDA For. Serv. Gen. Tech. Rep. PNW-145. Pacific Northwest For. and Range Exp. Stn., La Grande, Oreg. 18 p.

Klinka, K., F.C. Nuszdorfer, and L. Skoda. 1979. Biogeoclimatic units of central and southern Vancouver Island. B.C. Ministry of Forests, Victoria, B.C. 120 p.

Knight, S., and A. Purcell. 1980. WILDHAB: wildlife-habitat relationships data base. USDA For. Serv., Pacific Northwest Region, Portland, Oreg. [349 p. + app.].

Krajina, V.J. 1965. Biogeoclimatic zones and classification of British Columbia. Ecology of Western North America 1:1-17.

Krueger, W.C. 1980. How a forest affects a forage crop. p. 3-7 In Beef cattle and range resources: 1980 progress report. Special Report 583. Agricultural Exp. Stn., Oregon State University, Corvallis, Oreg. 77 p.

Kuchler, A.W. 1964. Manual to accompany the map, potential natural vegetation of the conterminous United States. Amer. Geogr. Soc. Spec. Publ. 36, New York. 152 p.

Kuchler, A.W. 1977. The map of the natural vegetation of California. University of Kansas, Lawrence, Kan. 31 p. + map.

Laudenslayer, W.F., Jr. 1982. California wildlife/habitat relationships program: northeast interior zone. Volume 1 - introduction and species-habitat relationships matrix. Unpublished report. USDA For. Serv., Pacific Southwest Region, Calif. 161 p.

Laudenslayer, W.F., Jr., M.F. Dedon, and D.A. Airola. 1982. California wildlife/habitat relationships program: northeast interior zone. Volume 5 - computer users manual. Unpublished report. USDA For. Serv., Pacific Southwest Region, Calif. 25 p. + app.

Laymon, S.A. 1982. Administrative study of relationships between wildlife and management of mature and over-mature (old-growth) tree stands: supplemental report on a test of a spotted owl habitat suitability model. Unpublished report. Dept. of Forest and Resource Management, College of Natural Resources, University of California, Berkeley, Calif. [32 p.].

Leckenby, D.A., D.P. Sheehy, C.H. Nellis, R.J. Scherzinger, I.D. Luman, W. Elmore, J.C. Lemos, L. Doughty, and C.E. Trainer. 1982. Mule Deer. In Wildlife habitats in managed rangelands: the Great Basin of southeastern Oregon. USDA For. Serv. Gen. Tech. Rep. PNW-139. Pacific Northwest For. and Range Exp. Stn., LaGrande, Oreg. 40 p.

Lotspeich, F.B., and W.S. Platts. 1982. An integrated land-aquatic classification system. N. Amer. J. Fish. Manage. 2:138-149.

Lund, G.H., V.J. LaBau, P.F. Ffolliott, and D.W. Robinson (tech. coordinators). 1978. Integrated inventories of renewable natural resources: proceedings of the workshop. USDA For. Serv. Gen. Tech. Rep. RM-55. Rocky Mountain For. and Range Exp. Stn., Fort Collins, Colo. 482 p.

Marcot, B.G. (ed.). 1979a. California wildlife/habitat relationships program: north coast/cascades zone - introduction. Unpublished report. USDA For. Serv., Six Rivers National Forest, Calif. 133 p.

Marcot, B.G. (ed.). 1979b. California wildlife/habitat relationships program: north/coast cascades zone. Volume 1 - herp narratives. Unpublished report. USDA For. Serv., Six Rivers National Forest, Calif. [110 p.].

Marcot, B.G. (ed.). 1979c. California wildlife/habitat relationships program: north coast/cascades zone. Volume 2 - bird narratives. Unpublished report. USDA For. Serv., Six Rivers National Forest, Calif. [565 p.].

Marcot, B.G. (ed.). 1979d. California wildlife/habitat relationships program: north coast/cascades zone. Volume 3 - mammal narratives.

Unpublished report. USDA For. Serv., Six Rivers National Forest, Calif. 67 p.

Marcot, B.G. (ed.). 1979e. California wildlife/habitat relationships program: north coast/cascades zone. Volume 4 - species/habitat matrix. Unpublished report. USDA For. Serv., Six Rivers National Forest, Calif. [40 p.].

Margalef, R. 1969. Diversity and stability: a practical proposal and a model of interdependence. p. 25-37. In Diversity and stability in ecological systems. Brookhaven Symp. Biol. 22, Brookhaven Natl. Lab., Upton, N.Y.

Marsh, R.D. 1982. Macroclimatic processes of British Columbia. Working report. Air Studies and Program Management Section, Waste Management Branch, Ministry of Environment, Victoria, B.C. 16 p. + map.

Maser, C., R.G. Anderson, K. Cromack, Jr., J.T. Williams, and R.E. Martin. 1979a. Dead and down woody material. p. 78-95 In J.W. Thomas (tech. ed.). Wildlife habitats in managed forests: the Blue Mountains of Oregon and Washington. USDA For. Serv. Agric. Handbook No. 553, Washington, D.C. 512 p.

Maser, C., J.M. Geist, D.M. Concannon, R. Anderson, and B. Lovell. 1979b. Geomorphic and edaphic habitats. In J.W. Thomas and C. Maser (tech. eds.). Wildlife habitats in managed rangelands: the Great Basin of southeastern Oregon. USDA For. Serv. Gen. Tech. Rep. PNW-99. Pacific Northwest For. and Range Exp. Stn., LaGrande, Oreg. 84 p.

Maser, C., J.E. Rodiek, and J.W. Thomas. 1979c. Cliffs, talus, and caves. p. 96-103 In J.W. Thomas (tech. ed.). Wildlife habitats in managed forests: the Blue Mountains of Oregon and Washington. USDA For. Serv. Agric. Handbook No. 553, Washington, D.C. 512 p.

Maser, C., J.W. Thomas, I.D. Luman, and R. Anderson. 1979d. Manmade habitats. In J.W. Thomas and C. Maser (tech. eds.). Wildlife habitats in managed rangelands: the Great Basin of southeastern Oregon. USDA For. Serv. Gen. Tech. Rep. PNW-86. Pacific Northwest For. and Range Exp. Stn., LaGrande, Oreg. 40 p.

Maser, C., B.R. Mate, J.F. Franklin, and C.T. Dyrness. 1981. Natural history of Oregon coast mammals. USDA For. Serv. Gen. Tech. Rep. PNW-133. Pacific Northwest For. and Range Exp. Stn., Portland, Oreg. 496 p.

Maser, C., J.W. Thomas, and R.G. Anderson. 1982. The relationship of terrestrial vertebrates to plant communities and structural conditions. In J.W. Thomas and C. Maser (tech. eds.). Wildlife habitats in managed rangelands: the Great Basin of southeastern Oregon. Unpublished draft. USDA For. Serv., Pacific Northwest For. and Range Exp. Stn., LaGrande, Oreg. 41 p.

Mason, W.T., Jr. (tech. ed.). 1982. Research on fish and wildlife habitat. EPA-600/8-82-022. Office of Research and Development, Washington, D.C. 248 p.

Mason, W.T., Jr., C.T. Cushwa, L.J. Slaski, and D.N. Gladwin. 1979. A procedure for describing fish and wildlife: coding instructions for Pennsylvania - Volumes 1 and 2. FWS/OBS-79/19. USDI Fish Wildl. Serv., Kearneysville, W. Va. [n.p.].

McLelland, J.F. 1982. Forest classification. Chap. 3. In Forest and range inventory manual. Unpublished report. Inventory Branch, Ministry of Forests, Victoria, B.C. [52 p. and appendices].

Mealey, S.P., and J.R. Horn. 1981. Integrating wildlife habitat objectives into the forest plan. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 46:488-500.

Meehan, W.R. (tech. ed.). 1979. Preface. In Influence of forest and rangeland management on anadromous fish habitat in western North America. USDA For. Serv., Pacific Northwest For. and Range Exp. Stn., Portland, Oreg. 1 p.

Minnich, D.W. 1981. Management of prairie potholes and National Wildlife Refuse System lands. Trans. N. Amer. Wildl. Natur. Resour. Conf. 46:369-379.

Mitchell, W.R., and R.E. Green. 1981. Indentification and interpretation of ecosystems of the western Kamloops Forest Region. Volume I. Very Dry Climatic Region. Ministry of Forests, Kamloops, B.C. [180 p.].

Munro, J.A., and I.McT. Cowan. 1947. A review of the bird fauna of British Columbia. Special publ. no. 2. B.C. Prov. Museum, Dept. of Education, Victoria, B.C. 285 p.

Nelson, R.D., and H. Salwasser. 1982. The Forest Service wildlife and fish habitat relationships program. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 47:174-183.

Nyberg, J.B. 1982. Intensive forestry effects on deer and elk forage (E.P. 934-01): working plan. Preliminary draft. Ministry of Forests, Vancouver, B.C. 47 p.

Odum, E.P. 1971. Fundamentals of ecology. W.B. Saunders Company, Philadelphia, Pa. 574 p.

Palmer, K.A. 1982. Arboreal lichen cover and abundance in four ages of selective cut Engelmann spruce - subalpine fir (moist subzone): a preliminary study. Unpublished report. Research Branch, Ministry of Forests, Victoria, B.C. 39 p. + app.

Parker, I., and W.J. Matyas. 1981. CALVEG: a classification of California vegetation. USDA For. Serv. Regional Ecology Group, San Francisco, Calif.

Patten, B.C. 1971. A primer for ecological modeling and simulation with analog and digital computers. p. 4-121. In B.C. Patten (ed.). Systems analysis and simulation in ecology. Academic Press, New York, N.Y.

Patton, D.R. 1978. RUN WILD: a storage and retrieval system for wildlife habitat information. USDA For. Serv. Gen. Tech. Rep. RM-51. Rocky Mountain For. and Range Exp. Stn., Fort Collins, Colo. 8 p.

Peek, J.M., and P.D. Dalke (eds.). 1982. Wildlife - livestock relationships symposium: proceedings 10. For., Wildl. and Range Exp. Stn., University of Idaho, Moscow, Idaho. 614 p.

Peek, J.M., M.D. Scott, L.J. Nelson, D.J. Pierce, and L.L. Irwin. 1982. Role of cover in habitat management for big game in northwestern United States. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 47:363-373.

Pfister, R.D. 1982. Designing succession models to meet management needs. p. 44-53 In J.E. Means (ed.). Forest succession and stand development research in the Northwest. Proceedings of the Symposium held 26 March 1981, Corvallis, Oregon. Forest Research Laboratory, Oregon State University, Corvallis, Oreg. 170 p.

Platts, W.S., W.F. Megahan, and G.W. Minshall. 1982. Methods of evaluating stream, riparian, and biotic conditions. Unpublished draft. USDA For. Serv. Intermountain For. and Range Exp. Stn., Ogden, Utah. [n.p.].

Pojar, J. (ed.). 1983. Forest ecology. p. 221-318. In S.B. Watts (ed.). Forestry handbook for British Columbia:fourth edition. The Forestry Undergraduate Society, Faculty of Forestry, University of British Columbia, Vancouver, B.C.

Prather, M., and B. Burbridge. [n.d.]. Wildlife - habitat relationships: a holistic approach. Unpublished report. USDA For. Serv., Northern Region, Missoula, Mont. 77 p. + app.

Raleigh, R.F. 1982. Habitat suitability index models: brook trout. FWS/OBS-82/10.24. USDI Fish Wildl. Serv., Fort Collins, Colo. 42 p.

Ream, C.H. 1981. The effects of fire and other disturbances on small mammals and their predators: an annotated bibliography. USDA For. Serv. Gen. Tech. Rep. INT-106. Intermountain For. and Range Exp. Stn., Ogden, Utah. 55 p.

Rice, K. 1981. Special and unique habitats. In Wildlife/habitat relationships for national forests in Alaska. Unpublished report. USDA For. Serv., Region 10, Juneau, Alaska. [n.p.].

Rodiek, J., and J.W. Thomas. 1980. Wildlife habitat planning and landscape architecture. Landscape Research 5(3):12-16.

Root, R.B. 1967. The niche exploitation pattern of the blue-gray gnatcatcher. Ecol. Monog. 37(4):317-350.

Rowe, J.S. 1959. Forest regions of Canada. Bulletin 123, Forestry Branch, Department of Northern Affairs and Natural Resources, Ottawa, Ontario. 71 p. + map.

Rowe, J.S. 1972. Forest regions of Canada. Publ. No. 1300, Canadian Forestry Service, Department of the Environment, Ottawa, Ont. 172 p. + map.

Salwasser, H., J.C. Capp, H. Black, Jr., and J.F. Hurley. 1980. The California wildlife habitat relationships program: an overview. p. 369-378 In R.M. DeGraff (tech. coordinator). Management of western forests and grasslands for nongame birds. USDA For. Serv. Gen. Tech. Rep. INT-86. Intermountain For. and Range Exp. Stn., Rocky Mountain For. and Range Exp. Stn., and Intermountain Region, Ogden, Utah. 535 p.

Salwasser, H., and J.C. Tappeiner II. 1981. An ecosystem approach to integrated timber and wildlife habitat management. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 46:473-487.

Salwasser, H., and W.C. Unkel. 1981. The management indicator species concept in national forest land and resource management planning. Unpublished report. USDA For. Serv., Pacific Southwest Region, San Francisco, Calif. 10 p.

Salwasser, H. 1982. California's wildlife information system and its application to resource decisions. Cal-Neva Wildl. Trans. (January): 34-39.

Salwasser, H., S.A. Holl, and M. Ross (eds.). 1982a. Deer habitats in California: deer ecology and habitat relationships models for inventory, planning, and management. Unpublished report. USDA For. Serv., Pacific Southwest Region, Calif. 40 p. + app.

Salwasser, H., and W.F. Laudenslayer, Jr. 1982. California wildlife and fish habitat relationships (WFHR) system: products and standards for wildlife. Unpublished report. USDA For. Serv., Pacific Southwest Region, Calif. 24 p. + app.

Salwasser, H., I.D. Luman, and D. Duff. 1982b. Integrating wildlife and fish into public land forest management. Unpublished report. USDA For. Serv., Washington, D.C. 7 p.

Samson, F.B., and F.L. Knopf. 1982. In search of a diversity ethic for wildlife management. Trans. N. Amer. Wildl. Natur. Resour. Conf. 47:421-431.

Schamberger, M., and A. Farmer. 1978. The habitat evaluation procedures: their application in project planning and impact evaluation. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 43:274-283.

Schamberger, M., A.H. Farmer, and J.W. Terrell. 1982. Habitat suitability index models: introduction. FWS/OBS-82/10. USDI Fish Wildl. Serv., Fort Collins, Colo. 2 p.

Scharpf, R.W., and F. Dobler. 1982. Caves, cliffs, and talus slopes. In R. Brown (ed.). Oregon-Washington westside wildlife-forest relationships. Unpublished draft. USDA For. Serv., Portland, Oreg. [25 p.].

Schroeder, R.L. 1982a. Habitat suitability index models: pine warbler. FWS/OBS-82/10.28 USDI Fish Wildl. Serv., Fort Collins, Colo. 8 p.

Schroeder, R.L. 1982b. Habitat suitability index models: yellow-headed blackbird. FWS/OBS-82/10.26. USDI Fish Wildl. Serv., Fort Collins, Colo. 12 p.

Schroeder, R.L. 1982c. Habitat suitability index models: yellow warbler. FWS/OBS-82/10.27. USDI Fish Wildl. Serv., Fort Collins, Colo. 8 p.

Schroeder, R.L., and P.J. Sousa. 1982. Habitat suitability index models: eastern meadowlark. FWS/OBS-82/10.29. USDI Fish Wildl. Serv., Fort Collins, Colo. 9 p.

Schweitzer, D.L., C.T. Cushwa, and T.W. Hoekstra. 1978. The 1979 national assessment of wildlife and fish: a progress report. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 43:266-273.

Self, B.E., Jr. 1982. Public attitudes regarding selected wildlife issues in British Columbia. Fish and Wildlife. Bull. No. B-14. Ministry of Environment, Victoria, B.C. 56 p.

Severinghaus, W.D. 1981. Guild theory development as a mechanism for assessing environmental impact. Environ. Manage. 5(3):187-190.

Sheppard, J.L., D.L. Wills, and J.L. Simonson. 1982. Project applications of the forest service Rocky Mountain Region wildlife and fish habitat relationships system. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 47:128-141.

Shimamoto, K., and D. Airola (eds.). 1981. Fish and wildlife habitat capability models and special habitat criteria for the northeast zone national forests. USDA For. Serv., Calif. 260 p.

Short, H.L. 1982. Development and use of a habitat gradient model to evaluate wildlife habitat. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 47:57-72.

Short, H.L., and K.P. Burnham. 1982. Technique for structuring wildlife guilds to evaluate impacts on wildlife communities. USDI Fish Wildl. Serv. Spec. Sci. Rep.-Wildl. No. 244. Washington, D.C. 34 p.

Shugart, H.H., and D.C. West. 1980. Forest succession models. Bioscience 30(5):308-313.

Siderits, K., and R.E. Radtke. 1977. Enhancing forest wildlife habitat through diversity. Trans. N. Amer. Wildl. Natur. Resour. Conf. 42:425-434.

Smith, T.M., H.H. Shugart, and D.C. West. 1981. Use of forest simulation models to integrate timber harvest and non-game bird management. Trans. N. Amer. Wildl. Natur. Resour. Conf. 46:501-510.

Spencer, W.D. 1982. Administrative study of the relationships between forest management and furbearer habitat productivity: supplemental report on a test of a pine marten habitat suitability model for the northern Sierra Nevada. Unpublished report. Dept. of For. and Res. Manage., College of Natural Resources, University of California, Berkeley, Calif. [43 p.].

Stalmaster, M.V., R.L. Knight, B.L. Holder, and R.J. Anderson. 1982. Bald eagles. In R. Brown (ed.). Oregon-Washington westside wildlife - forest relationships. Unpublished draft. USDA For. Serv., Portland, Oreg. [52 p. + app.].

Stein, J. (ed.). 1975. The Random House College Dictionary. Random House, Inc., N.Y. 1568 p.

Stevenson, S.K. 1982. Applying ecological classification systems to wildlife research and management: a problem analysis. IWIFR-3. B.C. Ministries of Forests and Environment, Research Branch and Fish and Wildlife Branch, Victoria, B.C. 151 p.

Strang, R.M. [n.d.]. Co-ordinated resource plans: room for improvement? Unpublished report. Faculty of Forestry, University of British Columbia, Vancouver, B.C. 11 p.

Stuber, R.J., G. Gebhart, and O.E. Maughan. 1982. Habitat suitability index models: largemouth bass. FWS/OBS-82/10.16. USDI Fish Wildl. Serv., Fort Collins, Colo. 32 p.

Summers, T.J. 1983. Terminology and concepts of the coastal zone: the coastal zone handbook. Lands Directorate, Environment Canada, Vancouver, B.C. 139 p.

Sundstrom, C. 1981. Introduction. In Wildlife/habitat relationships for national forests in Alaska. Unpublished report. USDA For. Serv., Region 10, Juneau, Alaska. [3 p.].

Takekawa, J.Y., E.O. Garton, and L.A. Langelier. 1982. Biological control of forest insect outbreaks: the use of avian predators. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 47:393-409.

Taylor, T.F. 1979. Species list of Alaskan birds, mammals, fish, amphibians, reptiles, and invertebrates. USDA For. Serv. Wildl. and Fish. Manage. Div. Rep. 82. Alaska Region, Juneau, Alaska. 102 p.

Telfer, E.S., and T.C. Dauphine. 1981. Problems facing wildlife habitat management on Canadian forest lands. Trans. N. Amer. Wildl. Natur. Resour. Conf. 46:358-368.

Thomas, J.W. 1979a. Introduction. p. 10-21 In J.W. Thomas (tech. ed.). Wildlife habitats in managed forests: the Blue Mountains of Oregon and Washington. USDA For. Serv. Agric. Handbook No. 553, Washington, D.C. 512 p.

Thomas, J.W. 1979b. Preface. In J.W. Thomas (tech. ed.). Wildlife habitats in managed forests: the Blue Mountains of Oregon and Washington. USDA For. Serv. Agric. Handbook No. 553, Washington, D.C. 512 p.

Thomas, J.W. (tech. ed.). 1979c. Wildlife habitats in managed forests: the Blue Mountains of Oregon and Washington. USDA For. Serv. Agric. Handbook No. 553, Washington, D.C. 512 p.

Thomas, J.W. 1982. Needs for and approaches to wildlife habitat assessment. Proc. N. Amer. Wildl. Natur. Resour. Conf. 47:35-46.

Thomas, J.W., R.G. Anderson, C. Maser, and E.L. Bull. 1979a. Snags. p. 60-77 In J.W. Thomas (tech. ed.). Wildlife habitats in managed forests: the Blue Mountains of Oregon and Washington. USDA For. Serv. Agric. Handbook No. 553, Washington, D.C. 512 p.

Thomas, J.W., H. Black, Jr., R.J. Scherzinger, and R.J. Pedersen. 1979b. Deer and elk. p. 104-127 In J.W. Thomas (tech. ed.). Wildlife habitats in managed forests: the Blue Mountains of Oregon and Washington. USDA For. Serv. Agric. Handbook No. 553, Washington, D.C. 512 p.

Thomas, J.W., and C. Maser (tech. eds.). 1979-1983. Wildlife habitats in managed rangelands: the Great Basin of southeastern Oregon. USDA For. Serv., Pacific Northwest For. and Range Exp. Stn., Portland Oreg.

Thomas, J.W., C. Maser, and J.E. Rodiek. 1979c. Edges. In J.W. Thomas and C. Maser (tech. eds.).Wildlife habitats in managed rangelands: the Great Basin of southeastern Oregon. USDA For. Serv. Gen. Tech. Rep. PNW-85. Pacific Northwest For. and Range Exp. Stn., LaGrande, Oreg. 17 p.

Thomas, J.W., C. Maser, and J.E. Rodiek. 1979d. Riparian zones. In J.W. Thomas and C. Maser (tech. eds.). Wildlife habitats in managed rangelands: the Great Basin of southeastern Oregon. USDA For. Serv. Gen. Tech. Rep. PNW-80. Pacific Northwest For. and Range Exp. Stn., La Grande, Oreg. 18 p.

Thomas, J.W., R.J. Miller, C. Maser, R.G. Anderson, and B.E. Carter. 1979e. Plant communities and successional stages. p. 22-39 In J.W. Thomas (tech. ed.). Wildlife habitats in managed forests: the Blue Mountains of Oregon and Washington. USDA For. Serv. Agric. Handbook No. 553, Washington, D.C. 512 p.

Thompson, C.E., A.P. Harcombe, and R.F. Ferster. 1980. An explanatory legend for the vegetation maps of the Pine-Moberly area. Working report. Terrestrial Studies Branch, Ministry of Environment, Kelowna, B.C. 21 p.

U.S. Department of Agriculture, Forest Service. 1978. Elk habitat/timber management relationships on eastside forests of the northern region, USFS. Unpublished report. USDA For. Serv., Northern Region and Montana Dept. of Fish and Game. 48 p.

U.S. Department of Agriculture, Forest Service. 1979a. Environmental consequences of timber harvesting in Rocky Mountain coniferous forests. USDA For. Serv. Gen. Tech. Rep. INT-90. Intermountain For. and Range Exp. Stn., Ogden, Utah. 526 p.

U.S. Department of Agriculture, Forest Service. 1979b. Guidelines for wildlife and fish habitat management in land resource management planning: a working paper. Unpublished report. Washington, D.C. 21 p.

U.S. Department of Agriculture, Forest Service. 1979c. Land management plan - Heppner planning unit: final environmental impact statement. USDA-FS-R6-FES (ADM)(76-06). Pacific Northwest Region, Umatilla National Forest, Oreg. 486 p.

U.S. Department of Agriculture, Forest Service. 1979d. Management of north central and northeastern forests for nongame birds. Workshop Proc. USDA For. Serv. Gen. Tech. Rep. NC-51. North Central For. Exp. Stn., St. Paul, Minn. 268 p.

U.S. Department of Agriculture, Forest Service. 1980a. Forest Service policy, goals, and objectives for wildlife and fish habitat management in the 1980's. Washington, D.C. 7 p.

U.S. Department of Agriculture, Forest Service. 1980b. Problem analysis: ecological analysis techniques for national assessments of wildlife and fish. Unpublished report. Rocky Mountain For. and Range Exp. Stn., Fort Collins, Colorado. 91 p. + app.

U.S. Department of Agriculture, Forest Service. 1981a. Amphibian narratives. In Wildlife and fish habitat relationships: Volume 1 - narratives. Rocky Mountain Region Headquarters, Denver, Colo. 37 p.

U.S. Department of Agriculture, Forest Service. 1981b. Bird narratives. In Wildlife and fish habitat relationships: Volume 1 - narratives. Rocky Mountain Region Headquarters, Denver, Colo. 411 p.

U.S. Department of Agriculture, Forest Service. 1981c. Fish narratives. In Wildlife and fish habitat relationships: Volume 1 - narratives. Rocky Mountain Region Headquarters, Denver, Colo. 178 p.

U.S. Department of Agriculture, Forest Service. 1981d. Mammal narratives. In Wildlife and fish habitat relationships: Volume 1 - narratives. Rocky Mountain Region Headquarters, Denver, Colo. 147 p.

U.S. Department of Agriculture, Forest Service. 1981e. Reptile narratives. In Wildlife and fish habitat relationships: Volume 1 - narratives. Rocky Mountain Region Headquarters, Denver, Colo. 80 p.

U.S. Department of Agriculture, Forest Service. 1981f. Relationships matrices: amphibians. In Wildlife and fish habitat relationships: Volume 2 - matrices. Rocky Mountain Region Headquarters, Denver, Colo. [18 p.].

U.S. Department of Agriculture, Forest Service. 1981g. Relationships matrices: birds. In Wildlife and fish habitat relationships: Volume 2 - matrices. Rocky Mountain Region Headquarters, Denver, Colo. [150 p.].

U.S. Department of Agriculture, Forest Service. 1981h. Relationships matrices: fish. In Wildlife and fish habitat relationships: Volume 2 -

matrices. Rocky Mountain Region Headquarters, Denver, Colo. [25 p.].

U.S. Department of Agriculture, Forest Service. 1981i. Relationships matrices: mammals. In Wildlife and fish habitat relationships: Volume 2 - matrices. Rocky Mountain Region Headquarters, Denver, Colo. [60 p.].

U.S. Department of Agriculture, Forest Service. 1981j. Relationships matrices: reptiles. In Wildlife and fish habitat relationships: Volume 2 - matrices. Rocky Mountain Region Headquarters, Denver, Colo. [34 p.].

U.S. Department of Agriculture, Forest Service. 1981k. Wildlife and fish habitat relationships: Volume 2 - matrices. Rocky Mountain Region Headquarters, Denver, Colo. [287 p.].

U.S. Department of Agriculture, Forest Service. 1981l. Wildlife and fish habitat relationships: Volume 1 - narratives. Rocky Mountain Region Headquarters, Denver, Colo. [886 p.].

U.S. Department of Agriculture, Forest Service. 1981m. Wildlife-habitat relationships - Region 2: data base user's guide. Unpublished report. Rocky Mountain Region Headquarters, Denver, Colo. [65 p.].

U.S. Department of Agriculture, Forest Service. 1982a. National forest system land and resource management planning: rules and regulations (36 CFR Part 219). Federal register 47(190): 43026-43052 (Thursday, September 30, 1982).

U.S. Department of Agriculture, Forest Service. 1982b. Proposed Forest Service fish habitat relationships system. Unpublished report. Boise, Idaho. 21 p.

U.S. Department of Agriculture, Forest Service. [1982?]. Wildlife/habitat relationships for national forests in Alaska. Region 10, Juneau, Alaska. [n.p.].

U.S. Department of the Interior, Fish and Wildlife Service. 1980a. Habitat as a basis for environmental assessment. 101 ESM. Division of Ecological Services, Washington, D.C. [28 p.].

U.S. Department of the Interior, Fish and Wildlife Service. 1980b. Habitat evaluation procedures. 102 ESM. Division of Ecological Services, Washington, D.C. [143 p.].

U.S. Department of the Interior, Fish and Wildlife Service. 1981. Standards for the development of habitat suitability index models. 103 ESM. Division of Ecological Services, Washington, D.C. [165 p.].

Van Barneveld, J.W. 1976. Vegetation: inventory, methodology, availability and interpretation. In Natural resource inventory. Centre for Continuing Education, University of British Columbia, Vancouver, B.C. 36 p.

Verner, J., E.C. Beedy, S.L. Granholm, L.V. Ritter, and E.F. Toth. 1980. Birds. p. 75-302 In J. Verner and A.S. Boss (tech. coordinators). California wildlife and their habitats: western Sierra Nevada. USDA For. Serv. Gen. Tech. Rep. PSW-37. Pacific Southwest For. and Range Exp. Stn., Berkeley, Calif. 439 p.

Verner, J., and A.S. Boss (tech. coordinators). 1980a. California wildlife and their habitats: western Sierra Nevada. USDA For. Serv. Gen. Tech. Rep. PSW-37. Pacific Southwest For. and Range Exp. Stn., Berkeley, Calif. 439 p.

Verner, J., and A.S. Boss. 1980b. Introduction and scope. p. 1-7 In J. Verner and A.S. Boss (tech. coordinators). California wildlife and their habitats: western Sierra Nevada. USDA For. Serv. Gen. Tech. Rep. PSW-37. Pacific Southwest For. and Range Exp. Stn., Berkeley, Calif. 439 p.

Verner, J., and A.S. Boss. 1980c. Using the publication. p. 9-10 In J. Verner and A.S. Boss (tech. coordinators). California wildlife and their habitats: western Sierra Nevada. USDA For. Serv. Gen. Tech. Rep. PSW-37. Pacific Southwest For. and Range Exp. Stn., Berkeley, Calif. 439 p.

Viereck, L.A., and C.T Dyrness. 1980. A preliminary classification system for vegetation of Alaska. USDA For. Serv. Gen. Tech. Rep. PNW-106. Pacific Northwest For. and Range Exp. Stn., Anchorage, Alaska. 38 p.

Walmsley, M.E., and J. Van Barneveld. 1977. Biophysical land classification techniques: the application to ecological classification of forest land in British Columbia. p. 41-119 In Ecological classification of forest land in Canada and northwestern U.S.A.. Centre of Continuing Education, University of British Columbia, Vancouver, B.C.

Walmsley, M., G. Utzig, T. Vold, D. Moon, and J. van Barneveld. 1980. Describing ecosystems in the field. RAB Tech. Pap. 2, Land Manage. Rep. No. 7. B.C. Ministries of Environment and Forests, Resource Analysis and Research Branches, Victoria, B.C. 225 p.

Watts, S.B. (ed.) 1983. Forestry handbook for British Columbia. The Forestry Undergraduate Society, Faculty of Forestry, University of British Columbia, Vancouver, B.C. 611 p.

White, M., R.H. Barrett, A.S. Boss, T.F. Newman, T.J. Rahn, and D.F. Williams. 1980. Mammals. p. 321-425 In J. Verner and A.S. Boss (tech. coordinators). California wildlife and their habitats: western Sierra Nevada. USDA For. Serv. Gen. Tech. Rep. PSW-37. Pacific Southwest For. and Range Exp. Stn., Berkeley, Calif. 439 p.

Whittaker, R.H. 1970. Communities and ecosystems. Macmillan, New York, N.Y. 162 p.

Wick, H.L., and P.R. Canutt. 1979. Impacts on wood production. p. 148-161 In J.W. Thomas (tech. ed.). Wildlife habitats in managed forests: the

Blue Mountains of Oregon and Washington. USDA For. Serv. Agric. Handbook No. 553, Washington, D.C. 512 p.

Wildlife Data Committee. 1982. Developing an integrated data system for wildlife management in B.C. Part I: General framework and the existing system. Unpublished report. British Columbia Ministry of Environment, Victoria, B.C. [n.p.].

Winn, D.S. 1976. Terrestrial vertebrate fauna and selected coniferous forest habitat types on the north slope of the Uinta Mountains. USDA For. Serv., Region 4, Wyo. 145 p.

Winn, D.S. 1980. Cassia wildlife habitat: a method of evaluation. Unpublished Report. USDA For. Serv., Intermountain Region, Ogden, Utah. 52 p.

Winn, D.S. 1982. WILD RAM progress report: wildlife and fish habitat relationships workshop (Portland, Oregon, March 24-26, 1982). USDA For. Serv., Intermountain Region, Ogden, Utah. 43 p.

Winn, D.S., R.W. Maw, and A. Wywialowski. 1982. WILD RAM user guide. Preliminary draft. USDA For. Serv., Intermountain Region, Ogden, Utah. 101 p.

Winn, D.S., and A. Wywialowski. 1982. WILD RAM: user guide supplement. Preliminary draft. USDA For. Serv., Intermountain Region, Ogden, Utah. 51 p.

Wischnofske, M.G. 1977a. Birds of Wenatchee National Forest. Unpublished report. USDA For. Serv., Pacific Northwest Region, Wenatchee National Forest, Wenatchee, Wash. [17 p.].

Wischnofske, M.G. 1977b. Wildlife habitat relationships of eastern Washington (Area 2). Unpublished report. USDA For. Serv., Washington, D.C. 193 p.

Wischnofske, M.G. 1978. Guide to wildlife habitat relationships. Unpublished report. USDA For. Serv., Pacific Northwest Region, Wenatchee National Forest, Wenatchee, Wash. 61 p. + app.

Young, J.A., D.W. Hedrick, and R.F. Keniston. 1967. Forest cover and logging: herbage and browse production in the mixed conferous forest of northeastern Oregon. Forestry 65:807-813.

Zamora, B.A. 1982. Understory development in forest succession: an example from the inland northwest. p. 63-69 In J.E. Means (ed.). Forest succession and stand development research in the Northwest. Proceedings of the Symposium held 26 March 1981, Corvallis, Oregon. Forest Research Laboratory, Oregon State University, Corvallis, Oreg. 170 p.

11. APPENDICES

11.1 Memorandum of Agreement: The Development of Wildlife Habitat Handbooks for the Forest and Rangelands of B.C. and Associated Projects

1.0 PURPOSE OF AGREEMENT

1.1 The purpose of this agreement is to define responsibilities and procedures for the participants in conducting the programme known as "The Development of Wildlife Habitat Handbooks for the Forest and Rangelands of B.C. and Associated Projects." The goal of this programme is to develop documents of use to wildlife and forest managers that aid wildlife habitat management in British Columbia (Schedule A.)

1.2 This agreement is subject to all Acts, and government policies and procedures relevant to the programme.

1.3 Definitions

1.3.1 Programme means all work and activities initiated under this agreement.

1.3.2 Programme project means a discrete piece of work directed to achieving the goal of the programme.

1.3.3 The participants in this agreement are:

The Ministry of Forests, Research Branch
The Ministry of Environment, Fish and Wildlife Branch
The Ministry of Environment, Surveys and Resource Mapping Branch
The Ministry of Provincial Secretary, Provincial Museum

The intent of the agreement is also supported by representatives of the University of British Columbia and Simon Fraser University.

1.3.4 Programme and programme project year extends from April 01 to the following March 31.

2.0 ADMINISTRATION OF THE PROGRAMME

2.1 The direction of the programme is guided by a Handbook Coordinating Committee.

2.1.1 The membership of the Handbook Coordinating Committee consists of representatives designated by the participants, a maximum of three (3) per Ministry.

2.1.2 The terms of reference for the Handbook Coordinating Committee are:

1. to review programme design
2. to implement and coordinate the activities of the programme
3. to provide information on the results of the programme
4. to plan future activities
5. to ensure integration with other activities and agencies

2.1.3 The quorum for the Handbook Coordinating Committee is four.

Decisions require seventy-five percent majority support for approval. Decisions that cannot be resolved by the Committee will be referred to senior levels in the participating agencies as appropriate to the issue.

2.1.4 A representative of the Surveys and Resource Mapping Branch will act as Chairman of the Handbook Coordinating Committee.

2.2 From time to time, working committees of regional personnel and other experts will be convened to address specific aspects of the progamme and programme projects.

2.3 The direct costs of the programme budget as well as indirect costs incurred by permanent staff, are the responsibility of the participants.

2.3.1 Consistent with 2.1.2., reasonable out of pocket travelling expenses will be paid to persons invited to participate in Handbook Coordinating Committee discussions.

2.4 The programme funds and staff are administered by each participant and are utilized consistent with the programme as approved by the Handbook Coordinating Committee.

2.5 Programme projects are administered by project leaders whose terms of reference include:

1. the design of the project(s)
2. the execution of the project(s) consistent with direction from the Handbook Coordinating Committee.
3. the reporting of results and identification of further activities.

3.0 RESPONSIBILITIES OF PARTICIPANTS

The responsibilities of participants are:

3.1 to provide representation to the Handbook Coordinating Committee;

3.2 to, where required, provide representation to any working committees concerned to address aspects of programme projects;

3.3 to circulate within their own agency, all pertinent information regarding the programme to ensure a thorough discussion of proposed activities;

3.4 to secure and administer where possible, adequate funding consistent with approval of programme projects by the Handbook Coordinating Committee;

3.5 to fully support the intent of the programme.

4.0 OWNERSHIP AND RELEASE OF INFORMATION

4.1 All findings, data, working plans, reports, theses, and other documents, whether complete or otherwise, that are made, prepared or received as a result of funding from the programme are the property of all participants represented on the coordinating committee.

4.2 All findings, data, working plans, reports, theses, and other documents of the programme will be made available upon request to all interested parties subject to prior approval by the Handbook Coordinating Committee.

5.0 OWNERSHIP AND ALLOCATION OF EQUIPMENT AND MATERIALS

5.1 Equipment, vehicles and materials purchased for programme projects are considered the property of the participant whose funds were used for the purchases.

6.0 EFFECTIVE DATE AND TERM OF AGREEMENT

6.1 This agreement becomes effective the day it is signed by the participants.

6.2 The undersigned or their designates may, on 14 days notice in writing, convene a meeting to discuss modifications to this agreement.

6.2.1 Modifications mutually agreed upon will come into effect 14 days thereafter.

6.2.2 Where agreement on modification cannot be reached, the matter shall be referred to the Deputy Minister level.

6.3 This agreement will continue in force until March 31, 1986.

6.4 This agreement may be extended by annual increments beyond the term of this agreement no later than the December 31st that precedes the termination date.

W. Young
Chief Forester
Ministry of Forests

Date: June 15, 1984

E. Anthony
Assistant Deputy Minister
Ministry of Environment

Date: June 29/84

Barry Kelsey
~~A.R. Turner,~~
Assistant Deputy Minister
Ministry of Provincial Secretary
and Government Services

Date: July 31/84

11.2 Wildlife Habitat Handbooks for the Forests and Rangelands of B. C. and Associated Projects: Final Proposal (June 1982)

INTRODUCTION

This report proposes the development of ways to improve planning the management of wildlife habitat. Included are rationale, objectives, component parts, participating agencies, procedures, and expected benefits. Developing improved ways for planning habitat activities are necessary if wildlife management objectives are to be reached.

In British Columbia, wildlife managers have two major opportunities to manage habitat. The first is to manage habitats directly by such techniques as manipulating vegetation, and controlling water levels. This approach is important but is necessarily costly, time-consuming, and geographically limited to small, highly productive or key areas.

The second approach opportunity is to manage habitats indirectly by influencing other resource managers to modify their activities for the benefit of wildlife. This approach is also important but it is currently slow, reactive, and costly.

The primary causes of these problems are insufficient staff, large volumes of work, and an inadequate organization of relevant knowledge. If these problems can be solved, then this second approach to planning habitat management can be greatly improved.

A promising solution to the knowledge problem is the habitat handbook developed by Jack Ward Thomas in Oregon. This publication organizes relevant knowledge of wildlife species in a readable, understandable format. The basis of this approach is recognition that:

(a) timber management affects large areas, is well financed and dramatically affects wildlife habitat, while
(b) wildlife management affects small areas, has little financing, and has little influence on wildlife habitat.

The key to the handbook concept is that it provides the best existing knowledge on the habitat requirements of wildlife species and how forest activities affect these needs in an easily understandable format and language. Using this knowledge, a wildlife or forest manager can objectively analyze the effects of combinations or patterns of forestry activities on wildlife species and, consequently, on wildlife management objectives. It allows a manager to select the best route to meet objectives. The assumption of this approach is that providing suitable tools to the appropriate resource managers will improve the level and effectiveness of habitat management for wildlife.

The handbook approach has been widely adopted in the United States and is supported in principle by wildlife and forest managers in this province. For these reasons, a pilot project for British Columbia is proposed.

Can the Oregon approach work in British Columbia? The province is many times larger than Thomas' study area and ecologically more diverse. Land tenure patterns are different, and available staff and resources even more limited. Also, different levels of planning are needed, from strategic to operational. These additional problems in British Columbia increase rather than detract from the value for such a new approach to habitat management. They make this program especially attractive.

OBJECTIVE

The general purpose or goal of this proposal is to develop tools to aid the management of wildlife habitat in British Columbia. Given the complexity of the problems in this province, the two following projects are proposed as starting points:

A. Wildlife Habitat Handbook: The aim of this project is to produce wildlife habitat handbooks at the operational planning level (1:50,000) for the forests and rangelands of British Columbia. The project has two objectives:

   1. To develop analytical and interpretive systems that enable the production of wildlife habitat handbooks.

2. To produce habitat handbooks for all parts of the province.

B. Biotic Region Description: The aim of this project is to describe ecological requirements of terrestrial vertebrates at the strategic level. The project has four objectives:
   1. To define areas of similar biotic potential.
   2. To map these areas at a scale of 1:2,000,000.
   3. To describe the ecological requirements of terrestrial vertebrates appropriate to this level of detail.
   4. To provide strategic-level guidelines on opportunities and limitations for habitat management.

IT IS IMPORTANT TO REALIZE THAT THESE TWO PROJECTS ARE INTERRELATED BUT NOT INTERDEPENDENT.

PROCEDURE

The two projects are closely related to the responsibilities, interests, and expertise of several agencies. In recognition of these common features, a coordinating committee was set up in September, 1981 for the purpose of developing this proposal.

The current members of this group and their affiliation are as follows:

Fred Bunnell	Faculty of Forestry, U.B.C.
Wayne Campbell	Division of Vertebrates Zoology, Provincial Museum, Ministry of Provincial Secretary.
Don Eastman	Fish and Wildlife Branch, Ministry of Environment,
Rick Ellis	Research Branch, Ministry of Forests.
Bruce Pendergast	Terrestrial Studies Branch, Ministry of Environment.
Rod Silver	Fish and Wildlife Branch Ministry of Environment.

Since its inception, the committee drafted this project proposal; revised the draft in response to comments received from Wildlife and Habitat biologists, and administration in both Ministry of Environment and Forests; selected the first pilot area; chose a project leader; prepared a memo of agreement (now in final state of approval) and worked on the terms of reference for component projects.

A continuing need exists for directing, integrating and coordinating work related to the proposal's goal. The existing committee could meet this need with the following responsibilities:

A. Administrative Responsibilities:

1. To define agency responsibilities.
2. To set study and species priorities.
3. To define needs for staff and resources.
4. To approve allocation of resources.
5. To approve project timetables and set deadlines.
6. To resolve problems and, where necessary, refer these to authority for solution.
7. To monitor and evaluate the progress and technical merit of work accomplished.
8. To develop and implement a system for reporting progress.
9. To determine a way for approaching the technical aspects of the problem.
10. To ensure integration with other agencies and activities.

B. Technical Responsibilities:

1. To review and evaluate existing information.
2. To develop ways of summarizing and synthesizing information.
3. To develop mechanisms for presenting, communicating, and using information in a handbook type of format.
4. To identify resources and resource persons and provide ways for including them in the study.
5. To discover information gaps in order to identify future needs for research and management.

6. To choose a study area or study areas, as required.
7. To supervise and advise staff in the preparation of a prototype handbook.

WORKING SCHEDULE

A. Habitat Handbooks:

A five year period is required to complete this component of the proposal:

1982-83: complete pilot study with the production of the first handbook

1983-87: continue with systematic production of handbook for the province.

B. Biotic Region Description:

A two year period is required to complete this component of the proposal:

1982-83: complete final version of biotic region map

1983-84: complete associated text and publish final report.

FUNDING

Details of funding and staffing will be worked out by the Coordinating Committee. However, some initial plans have been made in anticipation that the proposal will proceed.

A. Habitat Handbook:

The Research Branch, Ministry of Forests and the Fish and Wildlife Branch have included a handbook activity in the current 1982-83 budget and in the 1983-84 budget submission.

The Terrestrial Studies Branch has committed staff to the project.

The Forestry Faculty may have access to money from a number of outside sources but, confirmed support has not yet been received.

The Provincial Museum will probably provide support through help from existing staff.

B. Biotic Region Description:
This project is directly funded by the Terrestrial Studies Branch, with indirect support by assistance from biologists in all agencies and universities.

EXPECTED BENEFITS

The general value of both projects is improved effectiveness and efficiency in planning habitat management. In addition, each project had its own set of expected benefits:

A. Expected benefits of Habitat Handbooks include:

1. Present principles and knowledge tailored to the ecosystems and species of each broad ecological unit.
2. Aid communication and understanding between forest and wildlife managers by stating explicity the technical base for habitat management guidelines.
3. Promote active management directed to specified objects rather than reactive management directed to maintaining everything, everywhere.
4. Reduce the time required for Fish and Wildlife Branch staff to comment on development plans.
5. Identify information gaps and testable predictions regarding impacts on wildlife, both of which are valuable in revising and updating understanding.
6. Provide choices for resource managers by outlining expected consequences of their actions.

B. Expected benefits of the Biotic Region Description project are:

1. Provide a framework for ranking areas for large-scale work.

2. Provide a basis for the development of capability models.
3. Provide a basis for habitat protection and management guidelines at a strategic scale.
4. Assist in the indentification of critical wildlife areas.
5. Provide the basis for general guidelines until more detailed plans are available.
6. Identify information gaps in the habitat requirements of wildlife species.
7. Provide general stratification of the province for the development of species census guidelines.

RELATIONSHIP TO OTHER PROGRAMS

This proposal is related to a number of existing wildlife and wildlife habitat programs listed below. At this time, the relationship between these programs and the present proposal is not defined in detail, but the Coordinating Committee will have to ensure adequate integration and communication between all.

The related programs are:

a) wildlife management, Fish and Wildlife Branch, Ministry of Environment
b) habitat protection and management, Fish and Wildlife Branch, Ministry of Environment
c) wildlife and vegetation units, Terrestrial Studies Branch, Ministry of Environment
d) ecosystem mapping, Research Branch, Ministry of Forests
e) wildlife habitat research, Research Branch, Ministry of Forests
f) vertebrate atlas, Vertebrate Zoology, Provincial Museum, Ministry of Provincial Secretary
g) forest wildlife research, Forestry Faculty, U.B.C.
h) forest wildlife research, Canadian Wildlife Service

11.3 Personnel Contacted

R. Addison, Strategic Studies, Branch, Ministry of Forests, Victoria
D. Brooke, Kamloops Region, Ministry of Forests, Kamloops
E. R. Brown, USDA Forest Service, Olympia, Washington
F. Bunnell, University of British Columbia, Vancouver
T. Burke, USDA Forest Service, Colville, Washington
W. Campbell, Provincial Museum, Ministry of Provincial Secretary & Government Services, Victoria
R. Cavill, Interior Lumber Manufacturer's Association, Penticton
T. Chamberlin, Water Management, Ministry of Environment, Victoria
D. Demarchi, Surveys and Resource Mapping Branch, Ministry of Environment, Victoria
J. Dick, Planning and Assessment Branch, Ministry of Environment, Victoria
D. Eastman, Fish and Wildlife Branch, Ministry of Environment, Victoria
R. Ellis, Research Branch, Ministry of Forests, Victoria
R. Escano, USDA Forest Service, Missoula, Montana
D. Ferguson, Kamloops Region, Ministry of Forests, Kamloops
B. Fuhr, Surveys and Resource Mapping Branch, Ministry of Environment, Victoria
C. Fur, Kamloops Region, Ministry of Forests, Kamloops
D. Gibbons, USDA Forest Service, Anchorage, Alaska
P. Goldie, Fish and Wildlife Branch, Ministry of Environment, Kamloops
E. Hamilton, Research Branch, Ministry of Forests, Victoria
A. Harestad, Simon Fraser University, Burnaby
S. Hawthorn, Water Management, Ministry of Environment, Victoria
C. Highsted, Planning Branch, Ministry of Forests, Victoria
P. Holman, Fish and Wildlife Branch, Ministry of Environment, Kamloops
R. Howie, Parks Branch, Ministry of Lands, Parks and Housing, Kamloops
J. Hurley, USDA Forest Service, Sonora, California
B. Ivanco, Kamloops Region, Ministry of Forests, Kamloops
W. Landenslayer, USDA Forest Service, Nevada City, California
E. Lea, Surveys and Resource Mapping Branch, Ministry of Environment, Kelowna
T. Lester, Range Management Branch, Ministry of Forests, Victoria
D. Lloyd, Kamloops Region, Ministry of Forests, Kamloops
D. Low, Fish and Wildlife Branch, Ministry of Environment, Kamloops
R. MacDonald, Kamloops Region, Ministry of Forests, Kamloops

S. MacDonald, Fish and Wildlife Branch, Ministry of Environment, Kamloops

C. Maser, Bureau Land Management, Corvallis, Oregon

D. Meidinger, Research Branch, Ministry of Forests, Victoria

R. Mitchell, Kamloops Region, Ministry of Forests, Kamloops

R. Morley, Fish and Wildlife Branch, Ministry of Environment, Victoria

W. Munro, Fish and Wildlife Branch, Ministry of Environment, Victoria

B. Nyberg, Vancouver Region, Ministry of Forests, Burnaby

B. Pendergast, Surveys and Resource Mapping Branch, Ministry of Environment, Victoria

J. Pojar, Prince Rupert Region, Ministry of Forests, Smithers

R. Ritcey, Fish and Wildlife Branch, Ministry of Environment, Kamloops

J. Robinson, Kamloops Region, Ministry of Forests, Kamloops

F. Russell, Kamloops Region, Ministry of Forests, Kamloops

K. Sadoway, Research Branch, Ministry of Forests, Victoria

H. Salwasser, USDA Forest Service, Ft. Collins, Colorado

J. Sheppard, USDA Forest Service, Ft. Collins, Colorado

K. Shimamoto, USDA Forest Service, Tukelake, California

R. Silver, Fish and Wildlife Branch, Ministry of Environment, Victoria

N. Sprout, Surveys and Resource Mapping Branch, Ministry of Environment, Victoria

L. Stordeur, Research Branch, Ministry of Forests, Victoria

J. Thomas, USDA Forest Service, LaGrande, Oregon

R. Tucker, Kamloops Region, Ministry of Forests, Kamloops

J. van Barneveld, Surveys and Resource Mapping Branch, Ministry of Environment, Victoria

P. van Mohl, Kamloops Region, Ministry of Forests, Kamloops

T. Wallace, Kamloops Region, Ministry of Forests, Kamloops

J. Weinard, Kamloops District, Ministry of Forests, Kamloops

S. Wetmore, Canadian Wildlife Service, Delta

B. Wikeem, Research Branch, Ministry of Forests, Kamloops

M. Wilkins, Kamloops Region, Ministry of Forests, Kamloops

D. Winn, USDA Forest Service, Ogden, Utah

M. Wischnofske, USDA Forest Service, Wenatchee, Washington

11.4 Glossary

Adaptive Management a management approach that utilizes flexibility and interaction of experts, managers, and policy makers; at the minimum the adaptive approach makes assumptions visible, forces unanticipated questions, leads to design of alternatives, and defines the reasons for leaving things out (Holling 1982).

Agriculture and Rural Development Subsidiary Agreement (A.R.D.S.A.) a joint Federal and Provincial Government program to encourage development of the agricultural sector and food processing industry in rural British Columbia. The five-year funding agreement was signed in 1977 by the Federal and Provincial governments and is administered by a joint management committee.

Alpha Diversity see Diversity

Attribute category of information; attribute value - a "value" that a particular animal (plant) place/thing has been assigned for an attribute; attribute name - a "word" recognized by the computer as representing an attribute (Hurley and Asrow 1980).

Attribute Name see Attribute

Attribute Value see Attribute

Azonal applies to plant communities not restricted to one climatic vegetation zone; azonal communities may occur, in very similar compositions, in other zones (e.g. aquatic vegetation shows very little dependence on zonal climates) (Mueller-Dombois and Ellenberg 1974).

Beta Diversity see Diversity

Biogeoclimatic Classification a classification of ecosystems developed as a multi-level hierarchy with two primary sections of emphasis: ecosystem levels and zonal levels; now referred to as ecological classification. The ecosystem association is defined as all ecosystems capable of

producing vegetation belonging to the same plant association at climax; the ecosystem association is a group of related ecosystems physically and biologically similar enough that they have or would have similar vegetation at climax; ecosystem association is the fundamental theoretical unit in the classification. The uppermost classification level is biogeoclimatic, which consists of three commonly used taxonomic categories. Biogeoclimatic zone is a large geographic area with a broadly homogenous macroclimate; a zone has characteristic webs of energy flow and nutrient cycling and typical patterns of vegetation and soil; the ecosystem association that best reflects the zonal macroclimate is referred to as the zonal ecosystem association. Biogeoclimatic subzone, characterized by a distinct climatic climax (zonal ecosystem association), consists of unique sequences of geographically related ecosystems in which climatic climax ecosystems are members of the same zonal ecosystem association; a biogeoclimatic variant reflects further differences in the regional climate of a subzone; these climatic differences (e.g. drier, wetter, snowier, warmer, or colder) result in corresponding differences in vegetation, soil, and ecosystem productivity (Pojar 1983).

Biogeoclimatic Subzone see Biogeoclimatic Classification

Biogeoclimatic Variant see Biogeoclimatic Classification

Biogeoclimatic Zone see Biogeoclimatic Classification

Biogeocoenose terrestrial ecosystem that is a landscape segment relatively uniform in the composition, structure, and properties of both the biotic and abiotic environments and their interactions (Pojar 1983).

Biophysical Vegetation Classification a classification of ecosystems with a well developed hierarchy of biophysical units; the classification differentiates and classifies ecologically significant segments of the land surface, using a system reflecting ecological processes; the biophysical vegetation zone represents a geographical area in which the dominant vegetation of climax stands on similar soils and terrain is identical; biophysical vegetation subzone is differentiated on the basis of climate-related successional trends or growth form of the dominant

vegetation; a biophysical vegetation region is a geographical area in which the broad regional climate and physiography determine the definitive vegetation pattern; a region may be subdivided into biophysical vegetation sections distinguished on the basis of variations in the vertical sequence of zones or subzones or variations in the edaphic inclusions of zones. The vegetation landscape, the lowest level of biophysical unit commonly mapped, represents areas that are relatively homogenous with regard to soils, surficial materials, disturbance history, climate, and macro-vegetation; each landscape represents ecological land segments that are relatively similar with regard to management alternatives, constraints to use, and production of major crops; successional trends and climax vegetation are similar within a vegetation landscape (Harcombe 1981).

Biophysical Vegetation Region see Biophysical Vegetation Classification

Biophysical Vegetation Section see Biophysical Vegetation Classification

Biophysical Vegetation Subzone see Biophysical Vegetation Classification

Biophysical Vegetation Zone see Biophysical Vegetation Classification

Biotic Region see Wildlife Ecosystem Region

British Columbia Vertebrate Atlas Program a project of the Vertebrate Zoology Division of the British Columbia Provincial Museum. The objectives are to extract and transfer natural history and distribution data for vertebrates occurring in British Columbia from a variety of sources throughout North America; to maintain a provincial data bank where this information is consolidated, stored and easily retrieved; and to prepare a summary map of distribution and pertinent natural history information for each of the 587 species of vertebrates in British Columbia (Campbell and Harestad 1981).

CALVEG an acronym for a California vegetation classification system with an emphasis on dominant plants, developed by Parker and Matyas (1981).

Capability the potential of an area to produce a specific crop under specified technological controls (Hill et al. 1973). For ungulates in B. C. these

controls are those normally available to a wildlife habitat manager, such as prescribed burning or fire protection, prescribed grazing by cattle, and prescribed logging or slashing. Animal harvests or protection and predation or disease are not considered to have an effect on capability. Capability ratings are established on the basis of the optimum vegetational stage (successional stage) that can be maintained with good wildlife management practice (Anonymous).

Capability Ratings see Capability

Carrying Capacity the number and quality of organisms of a given species that can survive in, without causing deterioration of, a given ecosystem through the least favorable environmental conditions that occur within a stated interval of time (Ford-Robertson 1971); the number of animals of a given species that a habitat supports, measured at the low stage of any annual population cycle (after Allan 1958).

Competition struggle among organisms for food, space, and other requirements for existence (Random House Dictionary 1975); it occurs whenever two organisms make demands in excess of the supply; it is a universal characteristic of communities and is absent only in initial stages of succession and is greatest when individuals or species make similar or identical demands upon the same supply at the same time (Carpenter 1956).

Consumptive/Nonconsumptive Use in regards to the wildlife resource consumptive use is harvest or removal of wildlife by trapping or hunting; nonconsumptive use is nonhunting recreational and esthetic use involving wildlife.

Coordinated Planning the melding of resource management planning and action into one plan so that all resource goals are met (Thomas 1979c).

Coordinated Resource Management Plans (CRMP) resource plans developed to resolve land use conflicts (cattle grazing, recreation, timber production, and wildlife management) on Crown rangeland. The multiple use plan is developed by consensus of the planning group of users. Approved

activities and treatments are funded through the Agriculture and Rural Development Subsidiary Agreement (ARDSA).

Crown upper part of a tree or other woody plants, carrying the main branch system and foliage, and surmounting at the crown base a more or less clean stem; equivalent to tree canopy (Ford-Robertson 1971).

Crown Closure the progressive reduction of space between crowns as they spread laterally increasing the canopy density; equivalent to canopy closure (Ford-Robertson 1971).

Crown Cover the ground area covered by a crown, as delimited by the vertical projection of its outermost perimeter (Ford-Robertson 1971).

Decadent deteriorating; when used in reference to stand condition there are inferences of the loss of trees from the overstory and of the presence of disease, or indications of loss of vigor in dominant trees so that the mean annual increment is negative (Thomas 1979c).

Deferred Area Plan the planning process of the Ministry of Lands, Parks and Housing designed to resolve unalienated Crown land use options in areas identified as problem areas. Primary use is determined and the land will be given appropriate Crown land designation.

Diversity the relative degree of abundance of wildlife species, plant species, communities, habitats, or habitat features per unit of area (Thomas 1979c). Alpha diversity is the variety and relative abundance of biotic elements within a distinct habitat or stand of vegeation. Beta diversity refers to the changes in species and community pattern that occurs along an environmental gradient. Gamma diversity is a total number of species to be found in all the available habitats of a fairly large geographic area (Whitaker 1970).

Divisions see Ecosystem Region Classification

Domains see Ecosystem Region Classification

Ecological Classification see Biogeoclimatic Classification

Ecological Indicators a category of management indicator species that are members of associations that may be used as indicators to represent the effects of management on other species similarly adapted (Salwasser and Unkel 1981).

Ecological Reserves an area of Crown land reserved for ecological pruposes by the B. C. Ecological Reserves Act (1971); Ecological Reserves include: areas suitable for scientific research and educational purposes, areas that are representative examples of natural ecosystems, areas in which rare and endangered plants and animals may be preserved, and areas that contain unique and rare examples of botanical, zoological, or geological phenomena (Foster 1980).

Ecoregions see Ecosystem Region Classification

Ecosystem see Biogeocoenose

Ecosystem Association see Biogeoclimatic Classification

Ecosystem Region Classification an ecological land classification that divides the landscape into variously sized ecosystem units that have significance both for development of resources and for conservation of environment. The ecosystem units, called ecoregions, are arranged in a hierarchy defining successively smaller ecosystems within larger ecosystems. Subcontinental areas, called domains, are identified on the basis of broad climatic similarity. Domains are subdivided into divisions on the basis of climatic criteria and have definite vegetational affinities and similar regional climates. Divisions are subdivided into provinces on the basis of climax plant formation that geographically dominates the upland area of the province. Provinces are subdivided into sections on the basis of differences in the composition of the climax vegetation type. The latter two subdivisions are differentiated as highland or lowland. Highlands are distinguished where, because of the influence of altitude, the climatic regime differs substantially from that in adjacent lowlands so that there is complex vertical climate-vegetation-soil zonation (Bailey 1983).

Ecotone the area influenced by the transition between plant communities or between successional stages or vegetative conditions within a plant community.

Edatopic Grid a matrix for organizing ecological site data; commonly the two axes are nutrient regime and moisture regime; the pattern of ecosystems for a biogeoclimatic subzone can be projected onto the grid. The grid cells may be used for identifying earlier successional states of those ecosystem associations (Klinka et al. 1979; Pojar 1983).

Edge the place where plant communities meet or where successional stages or vegetative conditions within plant communities come together (Thomas 1979c).

Emphasis Species see Featured Species

Endangered Species populations immediately facing extinction in British Columbia and requiring special protective or enhancement measures or both to ensure their survival. Threatened species have declining or reduced populations, not endangerd at present, but which will become so unless protective or enhancement measures or both are initiated. Indeterminate populations are generally suspected of being threatened or endangered but for which information is too limited to allow designation in another category. Special populations are maintaining themselves but which require regular surveillance because of small numbers on restricted habitat (B. C. Ministry of Environment, Fish and Wildlife Branch 1979).

Enhancement in wildlife habitat management it refers to the improvement of present habitat suitability towards potential capability using improvement techniques normally available to a manager (see Capability).

Environment and Land Use Committee (ELUC) a provincial level committee of cabinet ministers with broad powers of policy formulation and decision making in resource management and land use matters (B. C. Ministry of Forests, Information Services Branch 1980c).

Environment and Land Use Technical Committee (ELUTC) a provincial technical committee, composed of deputy ministers of the various ministries represented in the ELUC, that implement, sign, and review tasks requiring multi-ministry coordination (Environment and Land Use Technical Committee 1977).

Environment Protection Area (EPA) environmental sensitivity, a stratification criterion in forest classification, reflects the environmental, social, economic, and technological factors in force at the time of inventory. Environmental sensitivity factors are expressed in terms of Environmental Protection Areas, using two levels of constraints. Level one refers to lands not available for sustained timber production, whereas level two rating covers lands that are conditionally available to harvesting due to other resource values. Seven EPA categories are recognized: soil sensitivity, plantation and regeneration sensitivity, snow avalanche sensitivity, recreation sensitivity, wildlife habitat sensitivity, watershed sensitivity and fisheries sensitivity (Watts 1983).

Environmental Sensitivity see Environment Protection Area (EPA)

Evaluation in management, the structured process of assessing the pros and cons of alternative choices.

Evenness the relative abundance of biotic and abiotic richness elements; evenness is an equitability component or element of biological variety or diversity (Odum 1971; Siderits and Radtke 1977).

Fall Down Effect because a vast supply of mature and over-mature timber existed in the province of B. C. in the past, harvest of old growth timber was accelerated in order to minimize losses from fire, insects and disease, and in order to establish new, productive forests. Thus, the amount of timber available for future harvests would be less than the current approved rate of harvest and would approximate annual growth. This projected change, the fall down effect, will occur as the old growth timber is liquidated and the cut approaches the long run sustainable yield. Improved silviculture and utilization may partially compensate for this fall down (Watts 1983).

Featured Habitat selected habitat classes or elements of importance to the welfare of a group of wildlife species that are the focus of habitat management strategies. These habitats may be in short supply or more easily managed than individual species; also referred to as management indicator habitats.

Featured Species (1) species that are selected for special management consideration for production of relatively high numbers of selected wildlife species in particular places for particular purposes (Thomas 1979c); (2) a category of management indicator species that includes species commonly hunted or trapped or species of high value for nonconsumptive recreational uses (Salwasser and Unkel 1981).

Feed see Forage

Folio Plan original resource plan with an emphasis towards timber extraction and incorporating a set of resource inventory maps; used by the Forest Service as an aid to management resource decisions for a five-year planning period.

Forage any unharvested, noninjurious material edible by, and of nutrient value for, livestock or wildlife; may be referred to as feed; (foraging includes grazing and browsing activities (Ford-Robertson 1971)).

Foraging see Forage

Forest Administrative Units the Ministry of Forests is structured administratively into three levels: headquarters, regions, and districts (B. C. Ministry of Forests, Information Services Branch 1980c).

Gamma Diversity see Diversity

Game Species game species includes all big game (deer, elk, moose, caribou, mountain sheep, mountain goat, bison, antelope, bear, cougar, or wolf), small game, game birds, and furbearing animals and any other species designated by the Lieutenant-Governor in Council under the Wildlife Act

(1982); the harvest of these species is generally referred to as consumptive use of wildlife (B. C. Ministry of Environment 1981).

Goal a general description or statement of the purpose and direction of management; it should reflect perceived present and future need and be capable of being effectively pursued (B. C. Ministry of Forests, Planning Division 1978) (see also policy and objective).

Guild Block see Guilds

Guilds groups of species that exploit the same class of environmental resources in a similar way; this term groups together species, without regard to taxonomic position, that overlap significantly in their niche requirements (Root 1967); guild blocks are matrices derived from two resource gradients of importance to wildlife; axes may represent loci within the structure of a vegetative community where food sources or breeding occur (Short 1982).

Habitat Capability Models models that relate levels of population of a species to selected attributes of their habitat or models that associate habitat conditions with different population levels. These models generally address habitat conditions required by individual reproductive units within wildlife populations. Model variables are generally restricted to physical, chemical, or biological characteristics of habitats (Hurley et al. 1982).

Habitat Capacity see Carrying Capacity

Habitat Classification a classification system using taxonomic or ecological characteristics that are relevant to primary factors influencing animal-habitat relationships.

Habitat Components if major segments of the environment (i.e. surface cover, soil, land form, climate) are related to life requirements of the species (water, food, cover, reproduction, special needs) they can be termed habitat components; the description of habitat for a given species is equal to the totality of habitat components.

Habitat Handbook publication that organizes relevant knowledge of wildlife species and their use of habitat in a readable, understandable format; the key concept is that the handbook provides the best existing knowledge on the habitat requirements of wildlife species and on how forest activities affect these needs. The handbook is a tool to help managers to make better analyses and decisions in meeting objectives for diversity and featured species management.

Habitat Suitability Index Model a type of habitat capability model using habitat information with an emphasis on quantitative relationships between key environmental variables and habitat suitability. Models provide a numerical index of habitat suitability on a 0.0 to 1.0 scale, based on the assumption that there is a positive relationship between the index and habitat carrying capacity. Models should be viewed as hypotheses of species-habitat relationships rather than statements of proven cause-and-effect relationships (Schamberger et al. 1982).

Habitat Type in general, a classification unit of any habitat classification. Specifically, a habitat type is defined as all the area that has the potential of supporting one plant association; vegetation is used as the dominant indicator (Daubenmire 1968).

Handbook Areas subdivisions of British Columbia for the production of individual habitat handbooks, based on a broad level of wildlife ecosystem regions.

Highland see Ecosystem Region Classification

Home Range the area which an animal traverses in the scope of normal activities; not to be confused with territory (Thomas 1979c).

Indeterminate see Endangered Species

Indicator Species see Management Indicator Species

Indirect Habitat Management habitat management or manipulation done for purposes other than wildlife habitat improvement but exploited to accomplish wildlife management objectives (Thomas 1979c).

Integrated Management management approach derived from a combined influence of a number of interacting resource concerns; has the ultimate goal of maximizing the benefits for the concerned resources as defined by the management plan.

Life Forms for wildlife, a group of wildlife species whose requirements for habitat are satisfied by similar successional stages within given plant communities (Thomas 1979c).

Life History Categories see Life Requisites

Life Requisites wildlife behavioral functions that utilize different aspects of habitat (e.g. feeding, reproduction, shelter, and predator avoidance); equivalent to life history categories (Salwasser and Laudenslayer 1982).

Limiting Factors the environmental influence through which the toleration limit of an organism is first reached, which acts, therefore, as the immediate restriction in one or more of its functions or activities or in its geographic distribution (Hanson 1962).

Lowlands see Ecosystem Region Classification

Macroclimate Processes consists of climatic events and processes and the interactions between air and land, that are big enough to need treatment on a world or continental scale; the interaction of the macroclimate with physiography produces a variety of mesoclimates (Hare and Thomas 1979).

Management the taking of actions calculated to result in the achievement of a predetermined goal.

Management Indicator Habitats see Featured Habitats

Management Indicator Species (MIS) species selected by using predetermined criteria that become the species for which resource goals, objectives and standards are set. Four categories of management indicator species are defined (see recovery species, featured species, specific habitat indicators and ecological indicators).

Management Unit (MU) a geographical unit used for the purpose of defining the open hunting seasons for big game, small game, and game birds in British Columbia by the Fish and Wildlife Branch of the Ministry of Environment; these units are also used for inventorying animal populations (B.C. Ministry of Environment, Fish and Wildlife Branch 1982a).

Marginal Habitat a class of habitat suitability, as judged by observed animal density and/or frequency of use, that may be used on a regular basis by a wildlife species but does not contribute significantly over time to the maintenance of the population (Verner and Boss 1980a). (see also optimum habitat and suitable habitat).

Mature a loose term for the stage at which a tree or other plant has attained full development, particularly height, and is in full seed production; this concept is applicable to a crop or stand provided it is narrowly even-aged; thereafter a decline in vigor, health and, for woody species, soundness, marks the stage of overmaturity; in forest management, the mature stage is that at which a tree or stand best fulfills the main purpose for which it was maintained (Ford-Robertson 1971).

Mesoclimates see Macroclimate Processes

Model a formalized expression of a theory or of the causal situation that generated observed data (Ford-Robertson 1971).

National Forest in the United States, a Federal reservation, of forest, range, or other wild land, administered by the Forest Service of the U.S. Department of Agriculture under a program of multiple use and sustained yield (Ford-Robertson 1971).

Niche (Habitat) the peculiar arrangement of food, cover, and water that meets the requirements of a particular species (Hanson 1962).

Objective a statement describing specific management intent and direction; it is usually quantified, can be measured over time, and is the end results capable of being achieved through management at a specified administrative level (B.C. Ministry of Forests, Planning Division 1978). (see also goals and policy).

Old Growth the developmental or successional stage between mature and climax forests; old growth stands usually contain the following characteristics: mature and overmature trees in the overstory; stand development well into the mature growth stage; a multi-layered canopy with trees of several age classes; and standing dead trees and down material. Evidence of man's activities may be present but do not significantly alter the other characteristics and would be a subordinate factor in a description of such a stand (Bureau of Governmental Research and Service, University of Oregon 1982).

Operational Plan a detailed plan designed for specific objectives and for utilization for on-site management; it identifies what site-specific measures must be taken to achieve resource management objectives (e.g. cutting plan, prescribed burn plan).

Optimum Habitat a class of habitat suitability that is the best quality habitat for a species, as judged by high breeding density or frequency of use for feeding or nesting cover (Verner and Boss 1980a).

Planning Horizon the time frame over which a management plan is designed and applicable; in the B.C. Ministry of Forests the planning horizon is usually twenty years; for wildlife management, this period will allow realization of benefits from any wildlife or habitat enhancement activities.

Plant Community an area of relatively uniform vegetation; it is the vegetation component of an ecosystem and interacts with soils, climate, organisms, topography, parent material, and time (Pojar 1983).

Policy a statement on how the authority is to achieve stated goals and objectives and describes the framework within which courses of action are developed to meet these objectives (B.C. Ministry of Forests, Planning Division 1978). (see also goal and objective).

Population a community of individuals that share a common gene pool (Ford-Robertson 1971).

Population Viability the process of a population having the capability of existing and functioning as an independant unit on a specified area over a specified time under a set of anticipated environmental conditions; a viable population size is considered to be the minimum level necessary to avoid endangerment or extinction; viability is a function of six principal factors: population size and density, reproductive potential, dispersal capability, competitive ability, habitat conditions, and effective breeding pairs (Salwasser and Unkel 1981).

Preliminary Species Plans planning documents, subject to change, that explain in detail the setting of objectives, policies, and management prescriptions for 27 species or group of species in the province (B.C. Ministry of Environment, Fish and Wildlife Branch 1979).

Provinces see Ecosystem Region Classification

Provincial Forest an administrative category of Crown land designated for management of renewable natural resources and under the jurisidiction of the B.C. Ministry of Forests (B.C. Ministry of Forests, Planning Division 1979).

Range Management the art and science of planning and directing range utilization so as to secure sustained maximum production of livestock (as animals or meat), milk, and/or cut forage, consistent with other uses and conserving natural resources (Ford-Robertson 1971).

Recovery Species a category of management indicator species that is identified for population increase because the species is threatened or endangered.

Recruitment within a wildlife population, considered to be the addition of reproductive age individuals.

Referrals line agency requests for inter-agency review, prior to decisions on resource allocation, that are directed to various concerned agencies for comment on specific resource concerns to that agency.

Regional Wildlife Management Plan a plan developed by regional wildlife managers to provide specific and long-term policy direction and priorities for wildlife management; the plan describes natural and human resources of the region, outlines problems and opportunities, states objectives and supply and demand factors influencing each species or species group found in the region, and describes the deployment of resources during the five year management period (B.C. Ministry of Environment, Fish and Wildlife Branch 1982b).

Richness a component of diversity which is a measure of the relative degree or number of plant or wildlife species or both associated with particular habitat conditions (modified from Thomas 1979c).

Sections see Ecosystem Region Classification

Simulation Model a model that mimics or reproduces the time behavior of dynamic systems (Patten 1971).

Special see Endangered Species

Species Habitat Matrix a two-way matrix displaying some form of relationship between species use and habitat characteristics.

Species Habitat Relationships the functional relationship between a species and its habitat.

Species Narrative a summary of pertinent details of the natural history of wildlife species; information categories include: legal status, ecological status/abundance, distribution/habitat, special habitat requirements, breeding, territory/home range, food habitats, distribution

maps, selected references, and impact of management practices; also referred to as species note.

Species Note see Species Narrative

Specific Habitat Element a habitat element, upon which wildlife often depend, that is not implied by the habitat class; the presence of the element is either preferable or essential to the achievement of potential capability; elements are differentiated according to those consumed as diet items, and those used as a "substrate" for feeding, reproduction, or cover.

Specific Habitat Indicators species with potentially limiting habitat requirements (=low versatility scores [Thomas et al. 1979e]) that may be significantly affected by anticipated management activities.

Stability the ability of an ecosystem, when changed from a steady state, to develop forces that tend to restore it to its original condition (Margalef 1969).

Strategic Plan a plan, prepared by the Planning and Assessment Branch of the Ministry of Environment, that describes management objectives for part of a region for a twenty-year planning horizon; the plan is based on analysis of resource supply and demand for water, waste, air, fish, and wildlife; the plan also includes a description of management programs which reflect priorities established by regional plan (e.g. regional wildlife management plan).

Structure the distribution and representation of age and/or size classes and of crown or other vegetation classes in a vegetation stand (Ford-Robertson 1971); the configuration of elements, parts, or constituents of a stand (Thomas 1979c).

Subunit a geographic subdivision of a Timber Supply Area, usually a watershed; at this level, spacial patterns of resource use are important for resolving resource use problems; subunit plans resolve resource use

conflicts and develop guidelines for forest management operations (B.C. Ministry of Forests, Planning Division 1978).

Succession the slow, orderly progression of changes in plant and animal community composition in an area from initial colonization to the attainment of the climax typical of that area (Summers 1983).

Successional Stage any floristically or structurally distinctive segment of a sere (temporary community in a successional sequence) (Daubenmire 1968).

Sufficient Abundance a concept in wildlife management that relates to provision of adequate numbers of a species to either maintain viable population levels or achieve increased production of desired species.

Suitable Habitat a class of habitat suitability, considered to be good habitat for the species, as judged by an intermediate breeding density or frequency of use for feeding or nesting (Verner and Boss 1980a). (see also marginal habitat and optimum habitat).

Sustained Yield the yield that a resource (e.g. forest, wildlife) can produce continuously from a given intensity of management; implies continuous production; a prime goal is to achieve, at the earliest practical time, a balance between production and harvest (modified from Ford-Robertson 1971).

Terrestrial Biotic Areas a geographic subdivision of British Columbia based on similarities in plant and animal species presence; thirteen terrestrial and two marine biotic areas have been delineated (Munro and Cowan 1947).

Territory the area which an animal defends, usually during breeding season, against intruders of its own species (Hanson 1962).

Threatened Species see Endangered Species

Timber Supply Area (TSA) a geographic subdivision of a forest administrative region defined for harvesting, planning and regulation; these provincial sustained yield units were formally called Public Sustained Yield Units;

TSA's are larger public land management units tributary to major manufacturing communities, with increased consideration of environmental and other resource concerns in determining rates of harvest (B.C. Ministry of Forests, Information Services Branch 1980a; Watts 1983).

Tree Farm License (TFL) a geographic area of granted Crown land forming private sustained yield units; the license commits the licensee to manage the entire area according to sustained yield principles under the general supervision of the Forest Service; licenses most common in the coastal area of British Columbia (Watts 1983).

Ungulate a hooved mammal; in British Columbia generally refers to wildlife species of the families Cervidae (deer family), and Ovidae (sheep family).

Unique Habitat a wildlife habitat (i.e. cliff, cave and talus) of special function not included within plant communities and successional stages or special habitats; geomorphic in nature (Thomas 1979c).

United States Wildlife Fish Habitat Relationships (WFHR) Program a wildlife program, coordinated by the U.S. Department of Agriculture, Forest Service, designed to integrate wildlife and fish population and habitat inventory with species-habitat relationships models, habitat evaluation procedures, and a research and monitoring program to develop, test, and refine species-habitat ecology, knowledge, and procedures for evaluating habitat quality (Nelson and Salwasser 1982).

Vegetation Landscape see Biophysical Vegetation Classification

Wildlife all nondomesticated vertebrates (Thomas 1979c); under the Wildlife Act for British Columbia wildlife means raptors (vultures, eagles, falcons, hawks, owls, and their eggs), threatened species, endangered species, game, and any other species of vertebrates designated as wildlife by the Lieutenant-Governor in Council (B.C. Ministry of Environment 1981).

Wildlife Ecosystem Regions formerly called Biotic Regions, an ecological land class that integrates existing floristic and other types of classifications in a way that meets the needs for wildlife management and

planning; areas have similar biotic potential and are defined mostly on a combination of macroclimatic processes interacting with physiography, with some consideration of dominant vegetation and vertebrate distributions (Demarchi and Pendergast 1983).

Wildlife Management Area an area of Crown land set aside for the management of wildlife as designated by the Minister of Environment under the Wildlife Act (B.C. Ministry of Environment 1981).

Zonal Ecosystem Association see Biogeoclimatic Classification

Queen's Printer for British Columbia ©
Victoria, 1984

Canadian Cataloguing in Publication Data

Harcombe, Andrew, 1950-
Wildlife habitat handbooks for British Columbia

(Wildlife habitat research, ISSN 0825-2769 ; WHR-8) (Fish and wildlife report, ISSN 0701-581X ; no. R-10) (MOE technical report, ISSN 0821-0942 ; 8)

"A cooperative effort of the Ministry of Environment (Surveys and Resource Mapping Branch : Fish and Wildlife Branch) and the Ministry of Forests (Research Branch)".
Co-published by the Ministry of Forests.
Bibliography: p.

1. Wildlife habitat improvement - British Columbia. 2. Habitat (Ecology) - British Columbia. I. British Columbia. Surveys and Resource Mapping Branch. II. British Columbia. Fish and Wildlife Branch. III. British Columbia. Ministry of Forests. Forestry Division. Research Branch. IV. Title. V. Series. VI. Series: Fish and Wildlife report ; no. R-10. VII. Series: MOE technical report ; 8.

QL84.26.B7W37 1984 333.95'15'00711 C84-092138-1

© Copyright 1984. B.C. Ministry of Environment.
First Printing 1984.